The role of marine protected areas in enhancing biodiversity and ocean sustainability

MRes Thesis

by Naomi Townsend

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Contents

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Abstract

Human activities are greatly affecting the marine environment, reducing biodiversity and diminishing the fauna and flora at an unsustainable rate. Marine protected areas (MPAs) are a tool to help reduce the effects of these harmful impacts.

Several aspects of an MPA affect its success in achieving its ecological goals. For example a previous study suggested that age, size, no-take zone (NTZ) status, isolation and enforcement were the main factors contributing to the ecological success of the MPA. It is also known that tourism pressure can contribute to the ecological degradation of an MPA. These aspects vary widely between MPAs.

In this study I will examine the effectiveness of a range of MPAs across the world, and predict their ecological effectiveness based on the aspects above. I use a Bayesian belief network to predict the likely ecological success (i.e. enhancing stock sizes or increasing biodiversity) of 27 MPAs, modelled both in the absence and presence of potentially conflicting socio-economic and legal pressures.

This study suggests that isolation is the most important factor affecting an MPA's ecological success rate, while the incorporation of conflicting pressures; i.e. the location's effect on tourism, made little difference to the predicted ecological success. Enforcement influences many other success factors, which is why identifying and implementing policies that will support and increased enforcement are so important.

At present there are ongoing negotiations for new legal treaties to allow more large isolated MPAs in the high seas. However, establishing environmental management protocols for MPAs based on existing concepts such as ISO 14001 would ensure minimal fishing and tourist damage, as well as ensuring the establishment of long-term, well enforced MPAs.

The purpose of this research is to examine the effect marine protected areas (MPAs) have on enhancing and sustaining biodiversity, from both a scientific and legal perspective. Thus, the choice of methods used demonstrates the multiple levels of the project. MPAs are an intricate and complex legal tool, which rely on scientific research to enhance and improve their structure. They also require an efficient legal basis of rules and restrictions to ensure their required goals required are attained. That is why both science and legal tools have been used in this study.

Research engages in a black letter law approach to meet the aim of identifying enforcement and management, and analysing the best approaches to obtain the optimum level of results from an MPA. However, the legal framework can often overlook scientific results, and that is why I acknowledges that weaknesses can occur from black letter law methodology.

This research encompasses the result of MPAs through a scientific definition of success (measurable ecological benefits); therefore, scientific methods to review MPA success in enhancing biodiversity and being effective are also reviewed through science as well as law. A Bayesian belief network (BBN) was used to analyse 27 MPAs over a global scale, from both developed and developing regions, which varied greatly in terms of their different success factors (e.g. enforcement level, fishing restrictions). These MPAs were selected to cover a wide range of geographical areas, as well as to incorporate a wide range of sizes, ages, enforcement, fishing intensity and tourism intensity. A BBN is a method of integrating

different data types, in this case to define the probability of the success of the MPA. They work by defining beliefs of the strength of connections between nodes in the network, which can and should be based where possible on real data or evidence. In this case, they allow expert opinion to be combined with detailed literature analysis from different MPAs to define the ecological success of the MPA.[1]

Furthermore, this research uses environmental law methodology, to assist in the incorporation of external factors and non-legal factors into the legal reasoning.[2] The project incorporates desk-based research throughout to analyse the different marine laws in protecting and conserving ocean territory and life, both within different nations and at an international level.

[1] The connections and relative strengths of these connections are given for each BBN used, where values above 0.5 mean an increase in the affecter node will lead to a likely increase in the affected node, and a value less than 0.5 means an increase in the affecter node is likely to lead to a decrease in the affected node.

[2] Aðalheiður Jóhannsdóttir, "The significance of the default: A study in environmental law methodology with emphasis on ecological sustainability and international biodiversity law." [2009] PhD dissertation. Universitetsbiblioteket, 2009.

Introduction

The marine environment is facing a number of threats which are damaging fauna and flora at an unsustainable rate, causing irrevocable damage.[3] The damage occurring is causing risk to not only the oceans' survival but that of human kind and all living organisms.[4] Predominantly the destruction of the world's oceans and seas is instigated by the pressures of human activity, comprising but not limited to: pollution, climate change, fishery undertakings, tourism and coastal advances. [5] These acts are resulting in the deteriorating health of most marine ecosystems and diminishing marine biodiversity.[6] It is causing harm at levels which will inevitably cause endangerment of marine species, and therefore immediate action is necessary.[7] The consequences of inaction will be extreme, not just for the marine environment but for the earth as a whole.[8]

Fishing eradicates billions of fish each year from the ocean.[9] Unsustainable fishing, or harmful fishing practices, such as certain methods of bottom trawling, cause not only targeted fish numbers to deplete but also the death of vast quantities of bycatch (those species that are accidentally caught and left to die), as well as causing

[3] Boris Worm et al., 'Impacts of biodiversity loss on ocean ecosystem services' [2006] *314*(5800) Science 787-790
[4] Gov uk, '2010 to 2015 government policy: marine environment' (*GOVUK*, 8 May 2015) <https://www.gov.uk/government/publications/2010-to-2015-government-policy-marine-environment/2010-to-2015-government-policy-marine-environment> accessed 14 March 2018
[5] Joachim Claudet, *Marine Protected Areas: A Multidisciplinary Approach* (Cambridge University Press 2011) at foreword
[6] Jeremy Jackson et al., 'Historical Overfishing and the Recent Collapse of Coastal Ecosystems' [2001] 293(5530) Science 629-637
[7] Philippe Sands et al., *Principles of International Environmental Law* (3rd edn, Cambridge University Press 2012) 351
[8] ibid
[9] Terrance Hughes et al., 'Adaptive Management of the Great Barrier Reef and the Grand Canyon World Heritage Areas' [2007]36(7) A Journal of the Human Environment 586-592

damage to the sea bed and supporting marine habitats.[10] Even marine mammals such as dolphins are being caught on a regular basis when fishing for tuna[11]. Trawling depletes fish numbers, by tearing up the sea beds and other fragile habitats. This confirms that as well as removing fish, fishing can also greatly degrade or destroy marine habitats[12]. Even without considering the full ecosystem damage of fishing, 93% of the world's fisheries are now fully or over exploited.[13] The oceans and seas make up approximately 71% of the earth's surface, and the oceans hold around 96.5% of all water on earth and produces 50% of the world's oxygen.[14] Numbers like this enforce the oceans' importance and scale. Major disasters would occur on a global scale without a successful biodiverse marine environment. The seas and oceans provide an assured and healthy food resource, but without a healthy and biodiverse marine environment, this would not exist.[15] A severe crash in the economy could also occur due to trade and work loss,[16] as well as diminished tourism[17]. We therefore, need a robust protection policy in place to facilitate the recovery of biodiversity and fish stocks and help to repair damage.

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[10] WWF, 'Overfishing' (*WWF*) <https://www.worldwildlife.org/threats/overfishing> accessed 25 April 2018

[11] National Oceanic and Atmospheric Administration Fisheries, 'The Tuna-Dolphin Issue' (*NOAA Fisheries*, 9 February 2016) <https://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=228&id=1408> accessed 25 April 2018

[12] Oceana, 'Mounting evidence shows Danish sand dredging destroys cod and plaice habitat in the Sound' (*Oceana*, 22 June 2016) <http://oceana.org/press-center/press-releases/mounting-evidence-shows-danish-sand-dredging-destroys-cod-and-plaice> accessed 25 April 2018

[13] Food and Agriculture Organization of the United Nations Fisheries Department, 2018. *'The State of World Fisheries and Aquaculture 2018'* Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO

[14] USGS, 'How much water is there on, in, and above the Earth?' (The USGS Water Science School, 2 December 2016) <https://water.usgs.gov/edu/earthhowmuch.html> accessed 2 May 2018

[15] Gov uk, '2010 to 2015 government policy: marine environment' (n4)

[16] Steven Murawski, 'Definitions of overfishing from an ecosystem perspective' [2000] 57 ICES Journal of Marine Science 649–658

[17] ibid

In certain areas of the marine environment, legal designation policy systems are being put in place to ensure protection for the ocean,[18] and these are called Marine Protected Areas (MPA). MPAs are a tool which have been established to help ensure healthy ecosystems and enhance fish stocks. The definitive goal of MPAs is to work with other strategies to ensure the ocean's environment as a whole functions in a sustainable manner.[19] Sustainability as defined by the Brundtland report argues for "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[20] With reference to the marine environment the aim is to have a successful biodiverse environment status upheld at an optimum level, whilst forestalling depletion.[21] However, an optimum level has not been clearly defined.

MPAs are frequently used as a means to protect and promote the increase of ocean health and biodiversity.[22] In the last few decades, international policy and legislation has influenced the increase of the establishment of MPAs on a global scale.[23] However, spatial management measures for marine environments are often being accounted for by several legal instruments, and the legal definition of an MPA varies from country to country.[24] Consequently, different opinions and views of MPAs as a

[18] John Morelli, 'Environmental Sustainability: A Definition for Environmental Professionals' [2011] 1(1) Journal of Environmental Sustainability 1-9
[19] ibid
[20] Gro Harlem Brundtland, 'What is sustainable development?' [1987] Our common future 8-9
[21] ibid
[22] Utrecht Law Review 'Protected areas in environmental law introduction' [2009] 5(1) Utrecht Law Review 1-4
[23] ibid
[24] Patricia Breen, 'Temperate Marine Protected Areas and highly mobile fish: A review' [2015]105 Ocean & Coastal Management 75-83

management tool are held by different stakeholders, resulting in some instances benefiting the marine environment, and in others causing little, or even no successful ecological outcomes of an MPA.[25]

Some MPAs, constrain or prevent damaging activities to ensure conservation goals are met. This is important to achieve as ultimately, we desire our marine waters to be healthy and its biodiversity to be rich and prevent population collapse and extinction. However, with there being over 2,000,000 known marine species globally,[26] this creates a challenge when designating and managing an MPA to cater to the needs of these species due to them having an array of complex characteristics and life histories. To enable MPAs to protect biodiversity as much as possible, it is necessary to factor in these needs into the management strategies at the design stage and ensure connectivity of MPAs as a network.

Furthermore, varied approaches and levels of protection can leave the definition of MPAs seeming 'unclear'.[27] Nonetheless, the International Union for Conservation of Nature (IUCN) defines an MPA as, "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"[28]. Contrastingly, there are two predominant classifications for protected areas, the other being from the Conservation on Biological Diversity

[25] ibid
[26] Camilo Mora et al., 'How Many Species Are There on Earth and in the Ocean?' [2011] 9(8) PLoS Biology
[27] Natalie Bown et al., Contested Forms of Governance in Marine Protected Areas: A Study of Co-Management and Adaptive Co-Management (Routledge 2013) 2
[28] IUCN, 'Marine protected areas – Why do we need them?' (IUCN, 9 February 2010) < www.iucn.org/content/marine-protected-areas-—-why-do-we-need-them> accessed 13 May 2018

(CBD). [29] In contrast to the IUCN definition, the CBD defines an MPA as "a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives"[30]. In international law the CBD definition is binding, whilst several countries adopt the IUCN's definition and build it into their national laws.[31] The difference between the definitions is that the IUCN focuses on conservation as whole, and association with cultural values and ecosystem services; whereas the CBD emphases on specific conservation objectives, which could be open to more interpretation than the IUCN's definition.

Another issue can be seen with regards to how we understand and manage MPAs that exist outside of national jurisdictions, as they pose fundamental questions with regards to application and enforcement of international law.[32] At present there are only a few MPAs situated wholly outside of national jurisdiction, the Ross Sea reserve, which was established by the Commission for the Conservation of Antarctic Marine Living Resource,[33] is by far the largest MPA outside of national jurisdiction. All other MPAs exist within the territorial waters and/or exclusive economic zone of coastal states,[34] which should help to ensure their optimum management and enforcement of the laws. However, the enforcement of the policies and laws in place to ensure MPAs achieve their goals varies greatly from MPA to MPA, meaning enforcement effectiveness does not have a definite standardisation. Without

[29] Paul Goriup, *Management of Marine Protected Areas: A Network Perspective* (John Wiley & Sons 2017) 71
[30] United Nations. 1992. Convention on Biological Diversity. United Nations: New York
[31] Paul Goriup (n29) 71
[32] Kamrul Hossian and Kathleen Morris, 'Protecting Arctic Ocean Marine Biodiversity in the Area Beyond National Jurisdiction'[2017] The Future of the Law of the Sea 105-126
[33] Peter Sand, 'Marine protected areas and ocean stewardship: a legal perspective' [2018] Biodiversity 1-3
[34] ibid

standardisation, we cannot achieve constructive management, potentially making MPAs ineffective.

A high-profile study has suggested that MPA success appears to rely on several influencing factors. These factors are: No take, effective Enforcement, Old, Large and Isolated; also referred to as the NEOLI factors.[35] However, there is also much evidence suggesting that tourism can cause ecological decline, especially if poorly managed, as will be discussed below. There are of course other factors that influence success such as the initial ecological state at the time of designation and its potential biodiversity level (i.e. sandy areas vs coral reefs), but the above listed factors appear to be the most valuable. These factors are key influencers in the success of an MPA reaching its targets and increasing its biodiversity, and overall ocean sustainability.

MPAs vary enormously between countries, especially between the economically developed and undeveloped.[36] Countries which are more economically developed tend to have more MPA coverage, with less developed countries being "left behind in the race to build a comprehensive global MPA network"[37]. Throughout this thesis a diverse, global range of 27 case studies will therefore be referred to throughout and be the basis of the research.

[35] Graham Edgar et al., 'Global conservation outcomes depend on marine protected areas with five key features' [2014] 506(7487) Nature 216
[36] Peter Jones, *Governing Marine Protected Areas* (Routledge 2014) 12
[37] Sophie Marinesque et al., 'Global implementation of marine protected areas: Is the developing world being left behind?' [2012] 36(3) Marine Policy 727 - 737

Chapter 1 Overview of the factors which can influence MPA success

1.1 Tourism

Tourism can pose a great threat not just for MPAs but for sustainability and biodiversity on a global scale. Construction of tourist infrastructure can demolish habitats, effect water quality, cause disruption to the environment and its wildlife, and damage communities by over-development and disturbance of local culture.[38] However, eco-tourism (often considered akin to sustainable tourism) can promote conservation. Eco-tourism is defined by the IUCN as "Environmentally responsible travel to natural areas, in order to enjoy and appreciate nature (and accompanying cultural features, both past and present) that promote conservation, have a low visitor impact and provide for beneficially active socio-economic involvement of local peoples"[39]. Tourism is one of the greatest global industries bringing in high income, with the market continuing to grow.[40] It is necessary to distinguish between sustainable tourism, which is purposely planned from the start to conserve natural resource, educate local residents and tourists, and respect as well as support local culture; and conventional tourism, where it is not necessarily its intention to improve conservation or educate, and which can promptly impair an environment, and this may not benefit the local community.[41]

[38] Clevo Wilson and Clem Tisdell, 'Conservation and Economic Benefits of Wildlife-Based Marine Tourism: Sea Turtles and Whales as Case Studies' [2003] 8(1) Human Dimensions of Wildlife 49-58
[39] Hector Ceballos-lascurain, *Tourism, ecotourism, and protected areas: The state of nature-based tourism around the world and guidelines for its development* (Island Press 1996)
[40] K Babu, 'Sustainable Tourism: Benefits and Threats for MPA's' [2012] Social Science Research Network
[41] ibid

Where tourism is developed with the focus of maintaining the pristine natural environments, it can have many benefits creating an income to maintain and aid conservation work,[42] alongside benefiting local communities through employment and revenue generation[43]. This causes motivation for the community, and for those who have knowledge of the protected area to care and be conscientious in their efforts to promote sustainability with regards to conservation. With true eco-tourism the main goal is to sustain the environment and traditional cultures, unlike conventional tourism where financial profit is the main focus.

Tourism can have many positives in promoting sustainability and conservation for MPAs but equally can cause negative impacts. The Great Barrier Reef (GBR) in Australia has approximately 1.6 million tourists each year, it portrays both positives and negatives of tourism.[44] Tourism on the GBR is currently worth over £2.25 billion a year, with over 47,000 employees.[45] It provides work and income for locals and therefore benefits its community and economy.[46] A key tool in the management and protection of the GBR is the tourism industry, raising approximately 8 million AUS dollars each year from tourists and fees paid by operators. These funds contribute directly to the management of the GBR from the Australian Government through the Environmental Management Charge.[47] Tourism operators have been acting as stewards for nine years for the GBR, through voluntary actions and the high standard

[42] Clevo Wilson & Clem Tisdell (n38)
[43] K Babu (n40)
[44] Vicki Harriott, 'Marine Tourism impacts on the great barrier reef' [2004] 1(1) Tourism in Marine Environments 29-40
[45] ibid
[46] Authority, Great Barrier Reef Marine Park. "Great barrier reef outlook report 2014." (2014)
[47] ibid

tourism programme set.[48] The tourism community is progressively working to incorporate best practice for the marine environment.[49]

Yet tourism vessels can cause great environmental impacts: they can physically disrupt the ocean's fauna and habitats (i.e. through noise pollution as discussed below, or poor anchoring practices), as well as disperse chemical pollutants into the ocean.[50] The GBR in particular is vulnerable to damage due to high levels of tourism,[51] as it suffers from induced damage from boats due to ship grounding, anchoring, chemical spills, and waste/litter discharge, which causes great disturbance to the marine life.[52] Furthermore, the disturbance effects an MPA's effectiveness by causing a change in the ocean fauna's living pattern, which causes disruption to breeding, living and emigration.[53] Tourists can also trample on sensitive intertidal habitats, or cause damage to coral when snorkelling and swimming. This disruption to habitats can cause several other consequences aside from instantaneous damage, such as species to displace or decease, as well as longer lasting elusive changes, such as altering eating patterns and reproduction of marine species.[54]

[48] ibid
[49] ibid
[50] Jan Warnken and Troy Byrnes, 'Impacts of Tour boats in Marine Environments' [2004] Environmental impacts of ecotourism 99-123
[51] Leon Zann, 'The State of the Marine Environment Report for Australia (SOMER): process, findings and perspectives' [1996] 33(1-3) Ocean & Coastal Management 63-86
[52] Troy Byrnes et al., 'Environmental management of boating related impacts by commercial fishing, sailing and diving tour boat operators in Australia' [2016] 111 *Journal of Cleaner Production*, 383-398.
[53] ibid
[54] Jean Holder, 'Pattern and impact of tourism on the environment of the Caribbean' [1988] 9(2) Tourism management 119-127

Growing the tourism industry increases visitor numbers, and as such it brings hotels and other infrastructure developments, light pollution, augmented sewage pollution and a surge in demand for seafood and ocean activities.[55] With these pressures occurring in or around MPAs it can affect their conservation goals. These pollution aspects will affect ocean life,[56] causing impacts on life cycles, changes in natural occurrences, and potentially behavioural adjustments in marine fauna and flora.[57]

1.2 MPA Age

Age has been proposed as a highly influential factor in success, as the longer an MPA has been established the longer the ecological community should have had to recover.[58] The older an MPA is, the more likely it should be closer to achieving its targets, but each MPA does vary as some populations may take decades to recover.[59] Furthermore, and more precisely older MPAs should have higher fish density than the younger.[60] However, enforcement of an MPA can effect on whether age is a successful influencer, for example if the MPA is of an older age but there is not enforcement of the MPA, then compared to a younger MPA with high enforcement it is possible that it could be less successful.

[55] Peter Jones (n36) 37
[56] M Gregory, 'Chapter 11 Environmental and Pollution Aspects' [1989] 51 Elsevier Oceanography Series 291-324
[57] Blue planet II, David Attenborough (BBC, 2017)
[58] Philip Molloy et al., 'Effects of marine reserve age on fish populations: a global meta-analysis' [2009] 46(4) Journal of applied ecology 743-751
[59] R Myers et al., 'Maximum population growth rates and recovery times for Atlantic cod, Gadus morhua'[1997] 95(4) Fishery Bulletin 762-772
[60] Phillip Molloy et al. (n58)

1.3 Size

Evidence suggests that the bigger the MPA the more likely it will succeed in enhancing biodiversity and sustainability in that area, particularly where the MPAs are established to help fish populations recover from overfishing and restore and recover coral reefs.[61] There is a particular focus on size at present, which stems from the convention on biological diversity, 10th Conference of the Parties (COP10) in 2010.[62] COP10 has had a global influence on the size of MPAs, where a 2020 target was set which asked for at least 10% of coastal and marine areas to be designated as protected areas.[63] As previously mentioned, influencing factors need the cooperation of each other, to help influence their success. A deficit of MPAs in regards to size is that it may still allow for a wide range of human activities to partake there. This means size is actually not as effective as intended,[64] due to human activities damaging the ecosystems within an MPA that are meant to be conserved.[65]

Since COP10 there has been a clear trend towards the designation of larger MPAs, with several being in the million km^2. The Ross Sea MPA designated in 2016 is vast at 1,549,000km^2, making it the world's second largest MPA. The largest MPA is the Terres Australes MPA, which although was created in 2006 was expanded greatly to 1,662,766km^2 in 2016. Barrack Obama quadrupled the Papahanaumokakea Marine National Monument MPA in 2016, making it 1,510,000 km^2. With the world's three largest MPAs being established in the past eight years since COP10, it raises

[61] Benjamin Halpern, 'The Impact of Marine Reserves: Do Reserves Work and Does Reserve Size Matter?' [2003] 13(1) Ecological Applications 117 - 137
[62] Convention on biological diversity, 'Aichi Biodiversity Targets' (Convention on Biological Diversity, 2010) <https://www.cbd.int/sp/targets/> accessed 30 March 2018
[63] ibid
[64] Benjamin Halpern et al., 'A Global Map of Human Impact on Marine Ecosystems' [2008] 319(5865) Science 948-952
[65] ibid

concern that we are just making MPAs to reach percentage coverage targets. However, it could be that we have realised how effective MPAs are as a management tool and therefore, should be of a larger size to achieve desired results and sustainable future.

1.4 Location and Isolation

MPAs that are isolated have a higher success rate due to less human activity taking place. However, the reason an MPA is established is due to that specific area needing protection, often from fishing, which in many cases can be more prevalent close to shore, or to human settlements.

From the 27 MPAs examined in this paper some are highly isolated, such as the Ross Sea protected area in Antarctica, which as a result escapes heavy fishing and shipping pressures.[66] Due to the isolation Ross Sea has, it is largely untouched by humans, with recent analyses of anthropogenic impacts showing the Ross Sea is the least affected stretch of ocean,[67] thus influencing the nutrient rich waters.[68] Whereas Bunaken National Park, located off the coast of Indonesia, is highly populated with 22 villages inside the park which comprise approximately 30,000 people.[69] Most locals work as fishermen and a number are employed in tourism involving boats and

[66] Brian Clark Howard, 'World's Largest Marine Reserve Created Off Antarctica' (*National Geographic*, 27 October 2016) <https://news.nationalgeographic.com/2016/10/ross-sea-marine-protected-area-antarctica/>accessed 1 September 2018
[67] David Ainley, 'A history of the exploitation of the Ross Sea' [2010] 46(3) Antarctica 233-243
[68] Brian Clark Howard (n66)
[69] Pieter Van Beukering et al. "Case study 3: Bunaken National Marine Park (Indonesia)." *The Role of Marine Protected Areas in Contributing to Poverty Reduction* (2007)

dive guides.[70] This has caused the park to suffer from a slow but continuous degradation owing to coral mining, anchor damage, diving, trash pollution, and various harmful fishing methods.[71] The Bird Island Group MPA in South Africa although it is located very close to the busy Port Elizabeth, is surrounded by buffer zones and other protected areas on land and sea to help achieve its goals, and prevent further interference from human activity.[72] Recent studies have shown that the benefits of near shore MPAs may be greater than isolated MPAs for enhancing fish stocks, although isolated MPAs have a greater ability to protect more mobile species such as large predators.[73]

Scientists have now discovered that coral reef fish larvae determine which reef they choose to make their home by listening to the reef[74], as well as using acoustic cues to navigate, locate prey, avoid predators, and find mates[75]. However, in some areas of the ocean the reef may not be heard at all, due to large levels of anthropogenic noise.[76] This noise pollution is caused by several interfering activities such as boats and tourism. With the growing exploitation and exploration of the ocean this is

[70] Patrick Christie, 'Marine Protected Areas as Biological Successes and Social Failures in Southeast Asia' [2004] 42 American Fisheries Society Symposium 155-164
[71] Patrick Christie, 'Observed and perceived environmental impacts of marine protected areas in two Southeast Asia sites' [2005] 48(3-6) Ocean & Coastal Management 252-270
[72] L Pichegru et al., 'Industrial fishing, no-take zones and endangered penguins' [2012] 156 Biological Conservation 117-125
[73] J Cinner et al., 'Gravity of human impacts mediates coral reef conservation gains' [2018] 13 Proceedings of the National Academy of Sciences
[74] John Montgomery et al., 'Sound as an orientation clue for the pelagic larvae of reef fish and crustaceans'[2006] 51 Advances in Marine Biology 143-196
[75] Rob Williams et al., 'Quiet(er) marine protected areas' [2015] 100(1) Marine Pollution Bulletin 154-161
[76] S Simpson et al., 'Attraction of settlement-stage coral reef fishes to reef noise' [2004] 276 Marine Ecology Progress Series 263-268

significantly affecting marine life.[77] During the last century noise pollution from cargo ships, holiday ships, seismic testing, and drilling has increased and continues to grow.[78] Therefore isolation and location can also influence success through having minimal disturbance and limited noise pollution.

1.5 No take zones (NTZs) and fishing restrictions

NTZs can deliver a significant outcome with regards to sustaining and enhancing biodiversity.[79] They protect the habitats and location of targeted marine species in order to safeguard the populations, thus restoring the integrity of marine ecosystems.[80] NTZs can improve fisheries in several ways. These include: decreasing the fishing for susceptible species; influencing the growth of the abundance of over-fished stocks; streamlining enforcement and therefore, compliance; and lessening incidental fishing and by-catch.[81] As we can see, NTZs are highly influential in the success of MPAs as they promote the success through enhancing biodiversity and therefore, allowing MPAs to attain targets. The issue that occurs however, is that NTZs are only able to reach their maximum effect for success if there is enforcement supporting it.[82] Without enforcement people may

[77] Chao Peng et al., 'Noise in the sea and its impacts on marine organisms' [2015] 12(10) International journal of environmental research and public health 12304-12323

[78] A Slotte et al., 'Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast' [2004] 67(2) Fisheries Research 143-150

[79] Brock Bergseth, 'Effective marine protected areas require a sea change in compliance management' [2017]75(3) ICES Journal of Marine Science 1178-1180

[80] L Pichegru et al., 'Marine no-take zone rapidly benefits endangered penguin' [2010] 6(4) Biology letters 498-501

[81] Michael Lockwood et al., *Managing Protected Areas: A Global Guide* (Routledge 2012) 614

[82] Stuart Campbell et al., 'Weak compliance undermines the success of no-take zones in a large government-controlled marine protected area' [2012] 7(11) PLoS One e50074

continue to fish due to there being a low risk of being caught and no 'personal' consequence.

Another issue faced when establishing an MPA as an NTZ is disrupting local communities by removing traditions and livelihoods. Many undeveloped countries, particularly smaller ones and islands, rely on fishing to bring in an income and as a stable food resource.[83] This will demotivate locals to support conservation due to being at a job loss with a shortage in supply of food also.[84] To ensure that this does not occur MPAs need to establish a way to either limit fishing, so making certain areas no-take or with restrictions, e.g. no trawling or dynamite fishing; or to involve and support the community within its establishment, such as by getting them involved and supplying jobs like being a conservation ranger or researcher.[85] The Galapagos Marine Reserve is partially an NTZ and has demonstrated an effective way to monitor fishing.[86] By involving the fishermen and training them in how to fish sustainably, they feel involved and therefore motivated to help conservation. Fishermen work alongside the scientists, helping them monitor the health of the fish and crustacean population.[87]

[83] A Thorpe et al., 'Fisheries and poverty reduction' [2007] 2(085) CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources
[84] Neil Andrew et al., 'Diagnosis and management of small-scale fisheries in developing countries' [2007] 8(3) Fish and Fisheries 227-240
[85] Pauly Daniel et al., 'Towards sustainability in world fisheries' [2002] 418(6898) Nature 689
[86] G Edgar et al., 'Bias in evaluating the effects of marine protected areas: the importance of baseline data for the Galapagos Marine Reserve' [2004] 31(3) Environmental Conservation 212-218
[87] National geographic education staff, 'Case Study: Galápagos Marine Reserve' (*National Geographic*, 29 January 2011) <https://www.nationalgeographic.org/news/case-study-galapagos-marine-reserve/> accessed 2 May 2018

The Chagos Islands have helped to reinstate the Bigeye Tuna through its NTZ status, which was registered as vulnerable by the IUCN due to overfishing.[88] The Chagos MPA has helped maintain biodiversity and enhance population size, as well as helping to avert millions of accidental catches, for example prior to the designation approximately 10,000 sharks were caught by mistake each year.[89] At the opposite end of the size spectrum, Lundy Island also is a designated NTZ, and as a success measure it has achieved a 127% increase in the abundance of legal-sized lobsters[90], with the population and size of both crabs and lobsters outside as well as inside the NTZ increasing.[91]

MPAs that have been established as an NTZ can be more successful, specifically with the increased likelihood of enhancing biodiversity.[92]

1.6 Enforcement

As has been discussed above, MPAs can be designated and created with legislation and enforcement to help improve and protect areas from its stressors. [93] There are laws which could be used to prevent harmful activities such as fishing and tourism, as well as restrict those activities causing unintentional disruptions, such as noise. However, while it can appear that laws are lacking, in many cases there could simply

[88] Chagos Conservation Trust, 'Fish' (*Chagos Conservation Trust*, 2017) <http://chagos-trust.org/chagos/biodiversity> accessed 21 April 2018
[89] ibid
[90] Evan Moland et al., 'Lobster and cod benefit from small-scale northern marine protected areas: inference from an empirical before– after control-impact study' [2013] 280(1754) Proceedings of the Royal Society B
[91] WWF, 'Lundy Lobsters Bounce Back in UK's First No-Take Zone' (*WWF*, 22 July 2005) <https://www.wwf.org.uk/updates/lundy-lobsters-bounce-back-uks-first-no-take-zone> accessed 23 March 2018
[92] Mark Costello and Bill Ballantine, 'Biodiversity conservation should focus on no-take Marine Reserves: 94% of Marine Protected Areas allow fishing' [2015] 30(9) Trends in Ecology and Evolution 507-509
[93] Rob Williams et al. (n75)

be other inherent defects, such as a lack of enforcement and structural management, making them ineffective.[94] As such, laws may be adequate in some instances, but ineffectively implemented. If laws were successfully enforced, they may allow MPAs to achieve their targets. Hence there is a need to consider be a successful instrument, when used in combination with suitable management measures. With legislative frameworks in place, enforcement of MPAs has the potential to be the most powerful influencing factor. It may be likely that if we improved management it would allow for conservation targets to be achieved more efficiently, and potentially quicker.

However, one issue is that MPA law can appear vague.[95] The framework surrounding MPAs is lacking in defining clearly and with enough detail, what a 'successful' MPA is, leaving us unsure on what aims and objectives should be, and when we have actually met 'MPA success'.[96] Even in England, where the success of Marine Conservation Zones is clearly defined in law (to the EU standard of Good Environmental Status for certain species or habitat types) the definition is confusing, and scientifically obtuse. It essentially indicates that the species or habitat should not decline from what is currently there, but provides no legal guidance on magnitudes of change.[97]

[94] Angela Haren, 'Reducing Noise Pollution from Commercial Shipping in the Channel Islands National Marine Sanctuary: A Case Study in Marine Protected Area Management of Underwater Noise' [2007] 10(2) Journal of International Wildlife Law & Policy 153-173
[95] Tom Appleby and Peter Jones, 'The marine and coastal access act—a hornets' nest?' [2012] 36(1) Marine Policy 73-77
[96] J Gallacher et al., 'Evaluating the success of a marine protected area: A systematic review approach'[2016] 183(1) Journal of Environmental Management 280-293
[97] R Stafford et al., 'Simple, policy friendly, ecological interaction models from uncertain data and expert opinion' [2015] 118 Ocean & Coastal Management 88-96

MPAs require an effective enforcement mechanism, because without it, you could be left with 'a paper park'[98]. Some MPA networks are managed through different regional or international scales of management, dependant on the type of MPA.[99] This does not promote consistency and could cause MPAs not to achieve their maximum potential. For example where an MPA focuses on a mobile species, it may need to be managed at several spatial scales,[100] as some species may cross international boundaries; meaning the MPA may also be at such a large size due to covering migratory paths that it is in multiple national jurisdictions.[101] This can cause complications if an MPA is not enforced through international legislation and only national, meaning protection may be ineffective once the species has migrated across the national borders. This is why the IUCN places such importance on ensuring that countries have similar legislation and objectives, especially when focusing on crucially important species that require protection.

Effective enforcement does not just involve the legal basis but also how the MPA is maintained and monitored, such as the Statia National Marine Park is regularly patrolled to ensure park regulations are being abided by.[102] Other MPAs are more technologically advanced, such as the Galapagos Marine Reserve in Ecuador, where they use satellite based GIS technology to monitor activities to ensure tourists

[98] Rife Alexis et al., 'When good intentions are not enough… Insights on networks of "paper park" marine protected areas' [2013] 6(3) Conservation Letters 200-212
[99] William Gladstone et al., 'Development and management of a network of marine protected areas in the Red Sea and Gulf of Aden region' [2003] 46(8) Ocean coast management 741 - 761
[100] ibid
[101] Patricia Breen (n24)
[102] St eustatius national marine park, 'National Parks' (*Statia Tourism*) <http://www.statia-tourism.com/nature/explore-our-island/national-parks/> accessed 2 May 2018

observe and obey regulations set out.[103] The Galapagos MPA also trains locals on how to sustainably fish, using encouragement and education as enforcement, as well as scientists conducting surveys and monitoring the MPA frequently.[104] With the enforcement that the Galapagos MPA has it challenges prohibited activities and less damage is occurring; therefore, continues to promote biodiversity and sustainability. Fines and charges for violations of MPA rules are also a strong enforcer, such as the Bunaken National Park has heavy fines and potentially jail sentences that await those who breach the most rigorous rules governing the activities.[105] The breach of fishing in the NTZ areas of the Banaken MPA can be punishable with a jail sentence of 10 years alongside a fine of up to 2 million rupiahs.

Effective enforcement for the ocean and its habitats, however, can at times appear to outbalance the needs of humanity. A key example is the Chagos islands, a British Indian Ocean Territory as of 1965, [106] caused an uproar during its designation. The British government on 1st April 2010 declared title of the British Indian Ocean Territory as an MPA,[107] measuring 640,000 km^2, making it over twice the size of the UK.[108] In the 1960s-1970s the archipelago removed all Chagossian inhabitants from its islands, being approximately 1,500 people.[109] With no human intervention and activities it allows for the MPA to be uncorrupted and pristine, making it a highly

[103] National geographic education staff (n87)
[104] ibid
[105] M Erdmann, 'Who's minding the reef? Corruption and enforcement in Indonesia [2001] 8 SPC Live Fish Information Bulletin
[106] Charles Sheppard, *Coral Reefs of the United Kingdom Overseas Territories* (Springer 2013) 7
[107] Stephen Allen, *The Chagos Islanders and International Law* (Bloomsbury Publishing 2014) 284
[108] Chagos conservation trust, 'Chagos Marine Reserve' (*Chagos Conservation Trust*) < https://chagos-trust.org/chagos/overview > accessed 24 July 2018
[109] Owen Bowcott, 'Chagos islanders cannot return home, UK Foreign Office confirms' (*The Guardian*, 16 November 2016) <https://www.theguardian.com/world/2016/nov/16/chagos-islanders-cannot-return-home-uk-foreign-office-confirms> accessed 24 March 2018

biodiverse and sustained environment.[110] The issue was raised though that enforcement was unjust,[111] evicting Chagossians from their home in the pursuit of conservation appeared to be a huge balancing issue.[112] With a persistent legal battle between the Chagossians and the UK,[113] it appears that the inhabitants returning would jeopardise the marine environment and habitats within this MPA, and therefore they are not allowed to return.[114] Chagossians value fishing as a key source of employment and food, [115] therefore, would they really be able to endure a sustained society and future within an NTZ? The answer is most likely no, although they do support the MPA but disagree with the NTZ[116] with the alternative of removing the NTZ it would allow for damage to occur to the biodiversity and numbers to plummet within the MPA, ruining its sustainability.[117] Hence why enforcement although appears brutal and unjust is a highly important factor in regards to creating a successful MPA and protecting our oceans and its biodiversity.

Some MPAs have little enforcement, although the rules are set out, they are not abided by or ignored due to the lack of implementation. The Cabo Pulmo National

[110] Heather Koldewey et al., 'Potential benefits to fisheries and biodiversity of the Chagos Archipelago/British Indian Ocean Territory as a no-take marine reserve' [2010] 60(11) Marine Pollution Bulletin 1906-1915
[111] ibid
[112] ibid
[113] Press association, 'Chagos islanders go to supreme court in battle to be allowed home' (*The Guardian*, 22 June 2015) <https://www.theguardian.com/world/2015/jun/22/chagos-islanders-supreme-court-battle-return-home> accessed 24 May 2018
[114] Sandra Evers and Marry Kooy, *Eviction from the Chagos Islands: Displacement and Struggle for Identity Against Two World Powers* (BRILL 2011)
[115] ibid
[116] David Hughes, 'Chagos marine reserve decision 'ignored exiled islanders'' (*Independent*, 6 April 2010) <http://www.independent.co.uk/news/world/africa/chagos-marine-reserve-decision-ignored-exiled-islanders-1937297.html> accessed 28 April 2018
[117] Press association, 'Chagos islanders go to supreme court in battle to be allowed home' (n113)

Marine Park has endured and suffered pressures from commercial fishing in the past 10 years due to enforcement being lacked.[118] Both Mexican and American residents' desire for the MPA to have restricted fishing regulations and promote sustainable fishing practices, but without the required government support and implementing it is proving a difficult undertaking.[119] Conservation efforts are being assisted in the right direction but the financial aid and federal enforcement is currently scarce,[120] and therefore, needs dramatic improvement; otherwise the MPA will not achieve its targets and will be deficient in biodiversity thus unsustainable.

1.7 Other factors

Several other factors affect an MPA which can be considered in discussion and analysis, however, have not been contemplated in the Bayesian belief network that was carried out. This is due to the factors either not being an occurring element in all MPAs or being problematic to measure. Other factors that influence an MPAs success includes: the state the MPA was in when it was designated, such as an unspoiled reef with rich biodiversity; climate change; coral bleaching occurs there; and education, where a society is well educated about the MPA and conservation it is more likely to succeed,[121] however, those MPAs with no education or awareness are looked over and more likely to be ignored, as no one is aware, causing ineffectiveness.

[118] Baja life online, 'Welcome to Cabo Pulmo National Marine Park' (*Cabo Pulmo National Marine Park*) <http://www.cabopulmopark.com> accessed 7 May 2018
[119] ibid

[120] Baja life online, 'The Reef' (*Cabo Pulmo National Marine Park*) <http://www.cabopulmopark.com/thereef> accessed 7 May 2018
[121] Timothy McClanahan et al., 'A Comparison of Marine Protected Areas and Alternative Approaches to Coral-Reef Management' [2005] 16(14) Current Biology 1408-1413

The designation of MPAs and the legislation surrounding them persistently revolves around maintaining a balance between maximising ecological conservation goals and allowing limited human activities such as tourism and fishing.[122] MPAs are working to achieve an international goal, and therefore, as well as national laws there is international legislation at the core of enforcement.[123] Having a plethora of laws can prove to be confusing, although international legislation does act as a base for all laws, promoting a level of consistency. Having a consistency allows for a more strategic approach, where nations can learn and build from each other, to ensure success in sustainability and biodiversity in our marine environment. The world as a whole is focusing on resolving the issues of the depletion of natural resources, and losses of biodiversity within our oceans, and MPAs are the renovating tool, repairing the loss of biodiversity in our oceans.[124] This shows how important it is that we focus on the management and designation that surrounds MPA legislation.

Currently there is no international convention wholly devoted to marine spatial planning. However, in 1994 the United Nations Convention on the Law of the Sea 1982[125] (UNCLOS) encompassed relevant regulations.[126] The majority of MPAs that are already established are built on geographical principles within jurisdictional

[122] Peter jones et al., *Governing marine protected areas: getting the balance right* (UNEP 2011)
[123] B.C. O'Leary et al., 'The first network of marine protected areas (MPAs) in the high seas: The process, the challenges and where next' 36(3) (2012) Marine Policy 598-605
[124] ibid
[125] United Nations Convention on the Law of the Sea (Montego Bay) 10 December 1982, in force 16 November 1994; 21 ILM 1261 (1982) (1982 UNCLOS)
[126] Myron Nordquist and Satya Nandan, *United Nations Convention on the Law of the Sea 1982, Volume VII: A Commentary* (Martinus Nijhoff Publishers 2011)

borders founded on UNCLOS;[127] which allows for MPAs to be easier to manage due to having a clear set location, in which it can follow national laws. It provides a clear definition and the differentiations between zones of the ocean that are under national jurisdiction and those areas beyond. These areas beyond national jurisdictions are often designated as the high seas,[128] and because of the lack of precision and jurisdiction, they have weaker protection.

UNCLOS is often referred to as the constitution for the oceans,[129] and defines the different marine districts, where different coastal states can exercise jurisdiction.[130] Although it is not exhaustive in regards to elaborating tools and mechanisms for marine conservation, it does ensure coastal states, and fishing states in the high seas, "agree on the measures necessary to coordinate and ensure the conservation and development of such stocks"[131]. By having coastal states agreeing on such measures, it allows for MPA management and designation to run as smoothly as possible, with less confusion than if it was uncoordinated. Coordination also allows for targets and strategies to be comparable, and therefore allow for improvements and MPA system updates to be made more efficient and suitable. We are constantly learning about new factors, and what makes an MPA most effective, therefore this helps us to factor this learning into the management process strategy, making a practical adaption to achieve effectiveness.

[127] Paul Goriup (n29) 55
[128] Food and Agriculture Organization of the United Nations Fisheries Department, '*MPAs and MPA Networks in the high sea*' [2010] Annex 1
[129] Tommy Koh, President of UNCLOS III, *'A constitution for the Oceans'*
[130] Paul Goriup (n29) 89
[131] Art.63 UNCLOS (n125)

UNCLOS manages the maritime activities of countries, which must respect the marine environment in order to ensure that biodiversity is not depleted, thus achieving MPA targets. Furthermore, UNCLOS also promotes the protection of “rare or fragile ecosystems” along with where marine species and resources are “depleted, threatened or endangered”, safeguarding their habitats.[132] By safeguarding particular ecosystems, it shows a diverse range of protection needed.

Aforementioned, convention on biological diversity, 10th Conference of the Parties (COP10) have implemented an international 2020 objective,[133] which reinforces the concept that globally we see MPAs being a long term instrument, enforcing the idea that they should be used and respected to repair and sustain our oceans’ biodiversity. With this target in place MPAs can be recognised internationally, and therefore can be considered a key legislative tool that should be respected and abided by globally once established. The effectiveness of legislation helps to ensure that MPAs cause the oceans to be healthy, abundant and sustainable, as well as increasing the health of the oceans’ inhabitants. By enforcing MPAs this could allow for not only for the ocean itself to be sustained, but also generates an efficient and healthy environment in and out of water for the world as a whole.

The IUCN is a highly important governing body that has both state and non-governmental members, allowing for diverse opinions to help ensure the highest MPA success rate possible. Designation and management is carried out by the IUCN for MPAs, and therefore has a highly significant status in the MPA sector. Thus

[132] Art.194 UNCLOS (n125)
[133] DEFRA JNCC, 'South Dorset MPA' (*JNCC DEFRA*, 22 February 2017) <http://jncc.defra.gov.uk/page-7138> accessed 6 April 2018

making the IUCN highly respected on a global scale, influencing all countries to manage and designate MPAs at identical levels and by similar strategies. They also enable the legal aspect of an MPA to be recognised at an international level. Policies are set through voting at episodic conferences of the World Conservation Congress and by resolution.[134] By allowing the voting system it allows an overall consensus from those who have a vested interest and are knowledgeable in nature conservation.[135] This allows for precision when designating the correct category and management approach, meaning MPAs can meet their targets more efficiently. By coming to international unanimous decisions, it allows for all governmental and national parties to become a part of the ocean protection movement, motivating their decisions and input to be valued, thus allowing for more MPAs to be established enhancing global biodiversity and sustainability.

[134] Nigel Dudley and Marc Hockings, 'Marine protected area governance and effectiveness across networks' [2017] Management of Marine Protected Areas 69-87
[135] ibid

Table 1 IUCN categories for MPAs

Category	Characteristics	Primary Objective
Ia Strict Nature Reserve	Strictly set aside safeguarded areas that are established to protect and enhance biodiversity, as well as geological/geomorphological qualities. Human visitation is limited, to guarantee protection of the conservation principles. These protected areas can act as crucial indication areas for monitoring and scientific research.	To ensure protection of species, ecosystems and geodiversity features on a regional, national or global scale. These elements will have been produced entirely or predominantly by non-human dynamics, and will be damaged when exposed to all but very precautious human impact.
Ib Wilderness Area	Frequently large unmodified or marginally modified protected areas. They preserve their natural influence and character, with no enduring human habitation. Protected to reserve their natural condition.	To ensure current and future generations have the prospect to experience such areas they are to safeguard natural areas and their long-term ecological integrity. They are free from modern infrastructures, undisrupted by substantial human activities and where natural energies and progressions are dominating.
II National Park	An area that is set aside to protect large scale environmental procedures which is a large natural or near natural site. It is established to also safeguard ecosystems and species with the characteristic of the area. Thus providing an establishment for culturally and	To promote recreation and education, whilst protecting the natural biodiversity and the fundamental ecological structure, supporting the environmental progressions.

	environmentally scientific, spiritual, recreational and educational visitor opportunities.	
III Natural Monument of Feature	Areas that are generally quite small and have a high visitor value. Set to protect a certain natural monument, which can be a sea mount, geological feature such as a cave, land mount, submarine cavern or a living feature such as an ancient grove.	To protect the natural monument/feature and the associated habitats and biodiversity surrounding it.
IV Habitat/Species Management Area	In order to sustain habitats or achieve the necessities of certain species, many protected areas need frequent and active interventions. However, it is not a requirement of category IV. The management of these areas reflect the priority of protecting a specific habitat or species.	To sustain, conserve and reinstate species and habitats.
V Protected Landscape/Seascape	An area which has developed a distinctive character with a significant biological, ecological, scenic and cultural value over time due to the interaction with people and nature. Also where protecting the integrity of this interaction is fundamental to sustain and safeguard the area, and the nature conservation and values associated with it.	By using traditional management processes, it is priority to sustain and protect significant seascapes and landscapes, alongside the associated nature conservation and other principles created by the interactions with humans.

VI Protected area with sustainable use of Natural Resources	A normally large protected area, where majority is in a natural condition, and a part being under sustainable natural resource management. These areas conserve habitats and ecosystems, using traditional natural resource management systems and associated cultural values.	To sustain and protect the natural ecosystems alongside the use of natural resources, allowing for sustainable and conservation use to be mutually beneficial.

[136]

[136] Nigel Dudley, *Guidelines for Applying Protected Area Management Categories* (2008) Best Practice Protected Area Guidelines Series No. 21 IUCN: Gland, Switzerland

The IUCN classifies protected areas using one of six protected area management categories, MPAs are all designated for different reasons so have different management objectives which influence which category they fall into (see table 1).[137] Thus by establishing different categories this helps ensure a better management system, and when an MPA is established the most related category is associated with it, therefore implementing the most suitable management most suited. By having the most suitable management it allows for MPA protection to be efficient, and reach its designated goals.[138] The United Nations, several national governments and other international bodies, all recognise these categories as the global standard for recording and defining protected areas, and are incorporating them into government legislation.[139] By having a global recognition it allows for a clear process to be followed, allowing us to work on reaching the best management system possible for MPAs on a worldwide scale. Global recognition enables the majority of MPA processes to be similar and therefore uncomplicated, being a globally recognised legal instrument. By having this straightforward management system, it influences a more conscious effort to establish more MPAs and protect a higher percentage of the world's oceans, enhancing biodiversity and sustainability.

What is apparent is that by setting these categories it allows for a consensus as to what MPA significances are likely to be, and provides accommodation for multiple MPA objectives.[140] The first step in applying the management categories is to establish if the area meets the IUCN definition of a protected area, then classify the

[137] J Day et al., *Guidelines for applying the IUCN protected area management categories to marine protected areas* (IUCN 2012)
[138] Nigel Dudley (n136)
[139] ibid
[140] Nigel Dudley and Marc Hockings (n134)

most fitting category.[141] By having this system it allows categorisation of MPAs to be an easier task, helping inform and guide management appropriately to achieve the desired results and enhance sustainability.

To help decide the category most suited for an MPA, the 75% rule has been established. The rule establishes that the primary management aims should apply to at least three quarters of the MPA, thus helping determine the correct category, and therefore the best management strategy. Several MPAs could encompass specific zones which could be used for other uses such as fishing or tourism, in what is otherwise a strictly safeguarded MPA.[142] Within certain MPAs the remaining 25% can be movable, meaning designated zones can be adjusted, for example, where a fishing zone might be accessible can be moved occasionally in order to avoid over-fishing, allowing stocks and biodiversity to replenish in the previously fished in area.[143] If an MPA which is nested within a larger MPA is managed differently, a different category may be better suited, and therefore that encompassed MPA can have its own category.[144] Similarly different zones within an MPA can have their own categories also, as long as the zones are fixed and described in law.[145]

Research conducted by Costello and Ballantine established that the IUCN management categories may not be followed as expected due to 94% of MPAs still allowing for fishing to take place within.[146] This shows very few MPAs actually ban all

[141] Nigel Dudley (n136)
[142] Nigel Dudley and Marc Hockings (n134)
[143] Nigel Dudley (n136)
[144] M Emslie et al., 'Expectations and outcomes of reserve network performances following re-zoning of the great barrier reef marine park' [2015] 25(8) Current biology 1-10
[145] ibid
[146] Mark Costello and Bill Ballantine (n92)

types of fishing, implying that the IUCN categories are followed as a guideline and not as strictly as they are intended to be, and are being misapplied. Therefore, this suggests a management programme is yet to be established that successfully applies and works for all countries, especially where a culture may value and rely on certain aspects such as fishing.

Similar to the management process, the IUCN has also established a typology of governance types as to who governs an MPA, i.e. who has the responsibility and authority for the protected area in question (See table 2 below). This can help cater to the management system and requirements an MPA needs, as well as allowing for the needs of the potential governors such as stakeholders and the community. The involvement of those with a vested interest in an MPA, such as local fishermen etc., it ensures promotion and support for enhancing its effectiveness and achieving objectives such as the need for biodiversity and for reefs and habitats to be sustained.[147]

Table 2 Governance categories for MPAs

Type	Name	Description
A	Governance by government	☐ National or federal agency/ministry in charge ☐ Sub-national agency/ministry in charge ☐ Government-delegated management
B	Shared governance	☐ Diverse influences, collaborative management ☐ Pluralist management, joint management ☐ Several levels over frontiers – transboundary management
C	Private governance	☐ By a non-profit organisation e.g. university or NGO ☐ By an individual owner

[147] Nathan Bennett and Philip Dearden, 'Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand' [2014] 44 Marine Policy 107-116

		☐ By a profitable organisation such as a corporate company
D	Governance by indigenous peoples and local communities	☐ Native and local persons conserved territories ☐ An area declared and run by local the community- community conserved areas

[148]

The six management categories established by the IUCN also allows for an internationally recognised MPA management system to be in place, thus giving a clear representation of the types of MPAs in a country, and how they are being managed. By having this clear picture, it allows for all countries to maintain a similar level for their MPAs, and adapt, compare and review other MPAs. Albeit a logical operation, information provided in 2014 established that the IUCN management categories are not yet in full force, with only half of the world's MPAs having a management category assigned by governments.[149] Therefore, this management tool is only going to work at full effectiveness if all countries abide by the system to achieve the best outcome in enhancing MPA management and sustainability. Otherwise, if each country follows a different management process lines will become blurred, and, therefore, ineffective.

In the absence of internationally recognised standards for MPAs in regards to quality management and enforcement practices,[150] there are the globally recognised international organisation standardisation ratings (ISO), which is a highly valued

[148] Nigel Dudley (n136)
[149] D Juffe-Bignoli et al (2014). Protected Planet Report 2014. UNEP-WCMC: Cambridge, UK
[150] Myles Thompson et al., 'ISO 14001: Towards international quality environmental management standards for marine protected areas' [2008] 51(11) Ocean & Coastal Management 727-739

international leader[151] for quality (ISO 9000) and the environmental management standards (ISO 14000).[152] Therefore, it is argued that countries apply the ISO 14001 standard which is for environmental enforcement and management systems.[153] The environmental management standards faction (14000) have been enhanced and changed based upon considerations and agreements from an extensive base of stakeholder groups, which are accepted and highly valued by both private sectors and the public around the globe.[154] Primarily it is applied to terrestrial parks but, if applied to MPAs, the system can provide an adaptive system, which allows integration with prevailing practices.[155] By having this precedent already set in being applied to a natural environment, it could logically be applied to MPAs.

It is suggested that having an effective management system like the ISO 14000 would encourage a constant cycle of planning, implementing, reviewing and improving the procedures undertaken to meet the MPA environmental objectives. This should lead to sustainability and enhanced biodiversity,[156] with the system allowing for continuous improvement, meaning occurring problems can be resolved and reversed. Thompson et al. suggested adapting the ISO 14001 standard when it comes to MPA management.[157] MPAs are unique in terms of water being a moving body and with many migratory species. If an adaption was put in place of

[151] T Rotherham, 'Raising standards: IUCN and the future of ISO 14001 Issues and options' [2001] (09-01)Biodiversity Economics 88
[152] Myles Thompson et al. (n150)
[153] ibid
[154] Paula Murray, 'International Environmental Management Standard, ISO 14000: A Non-Tariff Barrier or a Step to an Emerging Global Environmental Policy' [1997] Journal of International Economic Law 577
[155] Myles Thompson et al. (n150)
[156] Mckinley and White, *The ISO 14000 essentials: a practical guide to implementing the ISO 14000 standard* (Canadian Standards Association 1996) 97
[157] Myles Thompson et al. (n150)

international standards for MPAs it would likely enhance success rates in national reserve networks, but mainly allow for a more connected transnational approach for MPA enforcement and management.[158] This would allow for MPAs to enhance sustainability and biodiversity at a more significant rate, allowing all objectives to be met.

Furthermore, through the application of the new clause 4 of the ISO 14001 to MPAs, it will promote the factoring in of environmental impacts and changes.[159] It does this by stating that when establishing an environmental management system, an organisation should start by defining the scope of management, which wholly varies upon an organisation's environmental policy, its conditions in which it operates and the nature of activities that occur there.[160] When looking at using the ISO 14001 for MPAs it should be adapted so that the MPA is considered the organisation, and it provides services such as tourism, habitat protection, and goods such as fishery resources. Flora, fauna, fisheries and tourism are examples of the operation units an MPA goes through which all have diverse activities occurring within and surrounding the MPA.[161] To define the MPAs management scope, activities that occur there will have to be evaluated, alongside the broadness of the range of those activities. The legislation behind the MPA and authority in place should also be considered, as well as the restrictions the MPA has.[162] By looking at the core influencing factors this can help complement the plan with the needs and attributes of the MPA, causing an

[158] Patricia Breen (n24)
[159] ISO 14001: Environmental management systems – specifications with guidance, International Organisation for Standardisation, Geneva, Switzerland (2004) p31
[160] ibid
[161] Myles Thompson et al. (n150)
[162] Graeme Kelleher and R Kenchington, *Guidelines for establishing marine protected areas* (Volume 3, IUCN 1991)

effective system to be in place. The structure is in place and therefore it could be implemented and adapted it to apply to all MPAs.

The Convention for Biological Diversity (CBD) entered into force in 1993 with the aim of protecting global biodiversity[163],[164] setting the key target that "at least 10% of each of the world's ecological regions will be effectively conserved (CBD Decision VII/30, Target 1.1)" by 2010[165]. This target could be viewed as vague as there was no definition of what 'effectively conserved' meant. COP10 has now adapted this target to be reached by 2020 as it was not achieved.

These targets have been criticised in that they result in designation of large MPAs to help meet percentage targets, rather than designating an MPA for a specific purpose and focusing on those areas that need help.[166] Our oceans are now appearing to be full of large, young MPA. However, this could also be argued as a positive result of MPA success. We have learnt the importance and power of MPAs, and therefore are designating them bigger than ever before. By the CBD setting this objective, it also allows for all countries to be working towards the same target, meaning marine protection on a global scale. However, does the CBD and COP10 set a standard? The targets are clear but lack guidance. We are now soon approaching 2020 and still have not reached the 10% target, therefore we need to take a look at management to reach this target, rather than just setting it and leaving countries to deal with

[163] Convention on Biological Diversity (CBD) (Rio de Janeiro, 5 June 1992) Strategic Plan: Future Evaluation of Progress
[164] Patricia Breen (n24)
[165] CBD (n163) division VII/30, 20 February 2004, in Report of the Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity.
[166] P Jones and E De Santo, 'Viewpoint – is the race for remote, very large marine protected areas (VLMPAs) taking us down the wrong track?' [2016] 73 Marine Policy 231-234

themselves. Standardisation is lacking, and this is why we should combine the management systems we have in place to ensure designated MPAs are being managed and monitored efficiently. If we combined the management systems of the ISO 14001 with the targets of the CBD and COP10, a clear structure would be set in place to help make these targets achievable. Instead we appear just to keep setting bigger targets, e.g. 30% of the oceans to be protected by 2030, when we have not even reached the original target as yet.[167]

Although all countries have been influenced by international law, enabling them to incorporate these laws into their own national laws, each country's laws will still vary from one to another.[168] The reason that the national laws vary, is due to each country having different stressors and factors influencing their laws and enforcement methods, at different levels and strengths.[169] With all these different legislations in place it makes establishing and managing MPAs a difficult task. The contrasting legal barriers and designations mean the lines of the legal map are blurred and confusing. The EU alone adopts more than 200 pieces of legislation that have direct effects on marine management and policy,[170] so when considering a global scale of legislation it is overwhelming. This is because we have so many overlapping laws, and there are questions as to which ones we should follow and which ones should

[167] ibid
[168] Suzanne Boyes and Elliott Michael, 'Marine legislation – The ultimate 'horrendogram': International law, European directives & national implementation' [2014] 86(1-2) Marine Pollution Bulletin 39-47
[169] Michael Elliott, 'Integrated marine science and management: Wading through the morass' [2014] 86 (1-2) Marine Pollution Bulletin 1-4
[170] Suzanne Boyes and Elliott Michael (n168)

we ignore?[171] Furthermore, it is suggested that there are gaps in the legislation which cause the legal perspective to appear unclear.[172]

International legal requirements stemming from international and EU law can be presented in complex structures known colloquially as 'horrendograms'.[173] Horrendograms illustrate the complexity of legislation currently being used to conserve and manage our marine, coastal and transitional waters (see figure 1 below). Figure 1 maps out the international, European and national laws currently set out and proposed to protect our marine environment.[174] The centre of the horrendogram displays the international treaties, protocols and conventions, which on a worldwide scale have been signed by many countries, who have all agreed to uphold them.[175] The horrendogram is a very complex structure, but here it establishes the vast amount of legislation in place on a global scale, and explains why it is viewed to be so complex. It shows the vast amount of legislation, illustrating how overwhelming it is. The authors of the horrendogram have not elaborated on the fact that once those laws are unpicked, one can then see that they do not promote high levels of protection and have left room for gaps and confusion. These gaps represent lack of detail, which result in MPAs not being able to reach their full potential of success when conserving the oceans. There is even such a lack of detail that it does not define the basics of what good conservation is; surely this needs to

[171] Raoul Beunen et al., 'Implementation and integration of EU environmental directives experiences from The Netherlands' [2009] 19(1) Environmental Policy and Governance 57-69
[172] Suzanne Boyes and Elliott Michael (n168)
[173] ibid
[174] ibid
[175] The blue boxes are international organisations, the orange boxes are global laws and agreements.

be the starting point of all laws surrounding MPAs to ensure the promotion of high level of biodiversity?

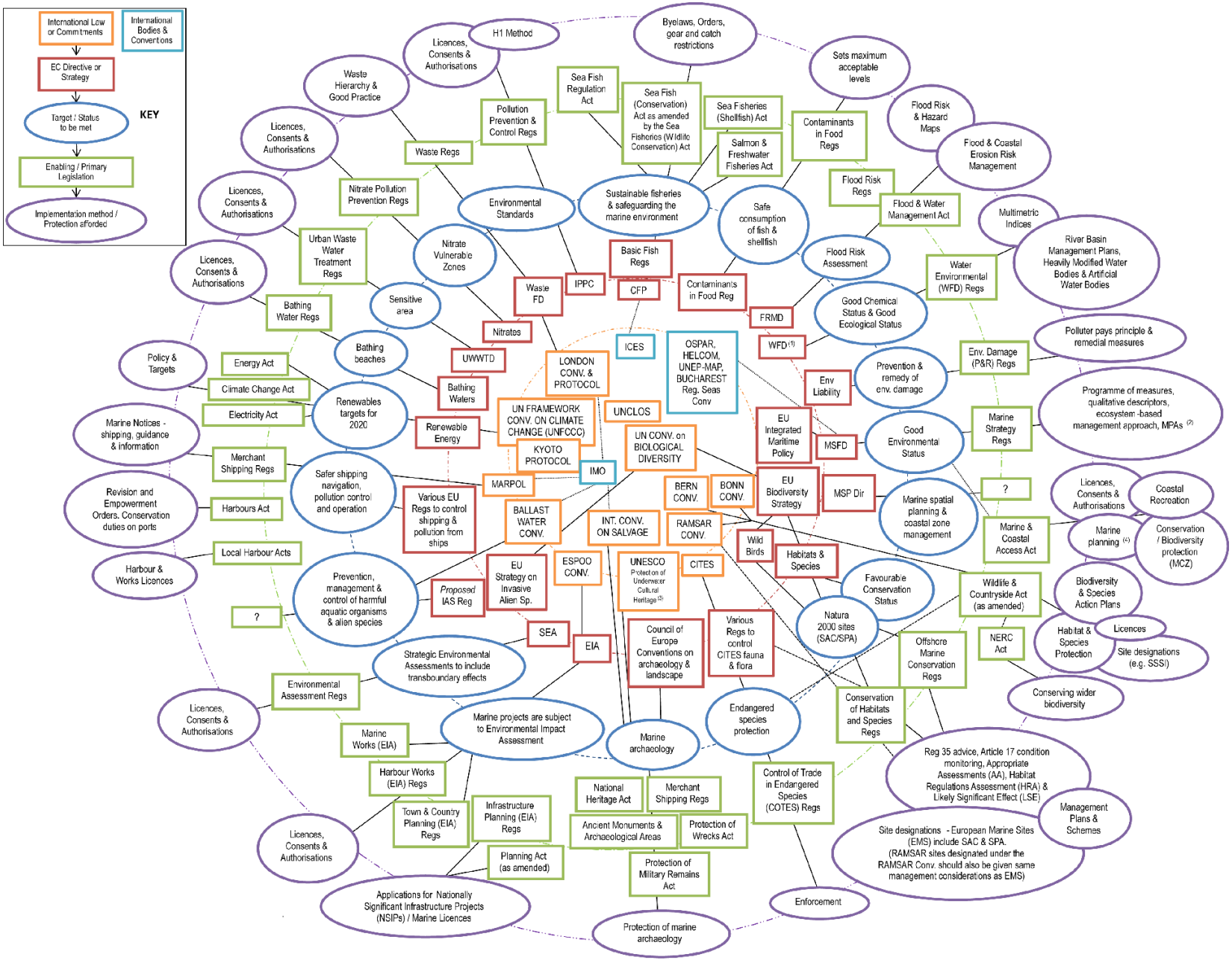

Figure 1: International, European and English legislation giving protection to the marine environment.

Each country has to adapt to its surroundings and stressors in order to achieve the most sufficient outcome, which allow MPAs to become effective and achieve its goals more efficiently.[176] More developed countries may focus on factors such as tourism, whereas more underdeveloped countries may focus on methods of fishing due to their reliance on it for income and as a food source; the focus could be to ensure only sustainable methods of fishing are used, deterring them away from harmful extractions such as trawling and dynamite fishing.[177] This is where the CBD is unfortunately weak and lacks guidance and information.[178] We need clear guidance if we are to have effective and sufficient MPAs. It is therefore suggested that a globally recognised management standard like the ISO 14001 might offer leadership and clarity if it is adapted to promote a standardised but bespoke MPA process.

UNCLOS remains one of if not the most fundamental conventions, and it provides a definition for the obligations and rights for coastal and other states in the differentiated marine legal areas.[179] Without UNCLOS providing the foundation it does, legislation and enforcement would be unclear and altered to what it is now.[180] Obligations and rights would be blurred, and therefore could be non-existent or weakly enforced, causing MPAs to be an ineffective tool, diminishing ocean

[176] Nathan Bennett and Philip Dearden, 'From measuring outcomes to providing inputs: Governance, management, and local development for more effective marine protected areas' [2014] 50(A) Marine Policy 96-110
[177] Mimi Lam, 'Of fish and fishermen: Shifting societal baselines to reduce environmental harm in fisheries' [2012]17(4) Ecology and Society
[178] Kerry ten Kate, 'Science and the Convention on Biological Diversity' [2002] 295(5564) Science 2371-2372
[179] Bleuenn Guilloux, 'Which International Law for Ocean and Climate?' [2016] 2(2) Ocean and Climate Scientific Notes 22 79-88
[180] ibid

biodiversity and making the ocean an unsustainable environment.[181] Therefore, ISO 14001 should take the basis of UNCLOS to help establish its management system. UNCLOS helps to define the legal lines between jurisdictions, and work on a basis where legislation is identical, because if stripped back to basics all jurisdictions appear to want the same outcome: sustainability, biodiversity and protection of the marine environment. Thus, making the combination of ISO 14001 and UNCLOS best suited for a global scale.

The idea of adapting the ISO 14001 would not only allow for effective management, but also establish a continuous improvement.[182] It would help to codify the current MPA management guidelines, providing the paramount practices internationally. Having the international similarity level would mean awareness could be raised, communication increased and public and community engagement in the planning process improved. By including the public and community, it would encourage positive behaviour in following the management system set out, acting as the system's enforcer, also reducing potential disagreements and eliminating confusion of multiple global systems. Thus meaning an efficient system would be in place for restoring our oceans, and helping to reverse the damage. If we had an internationally recognised management system that was applied globally to all MPAs, the knock-on effect from this standardisation would be to have an increase in the abundancy of flora and fauna,[183] thus generating positive impacts on the health of the marine environment,[184] and ultimately promoting the sustainability of our oceans.[185]

[181] ibid
[182] Mckinley and White (n156)
[183] Christie Patrick, 'Marine protected areas as biological successes and social failures in Southeast Asia' [2004] 42(42) American Fisheries Society Symposium 155-164
[184] Boris Worm et al. (n3)

One of the key causes of 'failure' for management is the mismatch between the enforcement to be put in place, and the measures needing to be taken to ensure an MPA achieves its objectives, and what the exact goals of the MPA are that it has been established to achieve.[186] If each MPA had a clear management plan which outlined its objectives, it would allow for targets to be achieved and biodiversity to increase abundantly at a more efficient speed, ensuring objectives would be achieved.[187]

When reviewing the influence and role of management and legislation within MPAs, what is apparent is the complexity of factoring scientific and legal concepts, which at times seem like "mixing water and oil"[188]. To remedy this problem, it is suggested that standardisation needs to be in place for MPAs to have an effective management system.[189] ISO 14001, with the influence of UNCLOS and the targets of CBD and COP, could be the standardisation that will ensure that our MPAs are managed sustainably, thus promoting greater biodiversity, and reaching their targets. Once we have an effective system in place with clear guidelines, it will allow a real difference in the way MPAs are viewed, and how long it takes for their targets to be met will considerably change for the better.

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[185] Pauly Daniel et al. (n85)
[186] Robb et al., 'Commercial fisheries closures in marine protected areas on Canada's pacific coast: the exception, not the rule' [2011] 35(3) Marine policy 309-316
[187] ibid
[188] Oliver Houck, 'Tales from a Troubled Marriage: Science and Law in Environmental Policy [2003] 302(5652) Science 1926-1929
[189] Myles Thompson et al. (n150)

Chapter 3 Factors affecting the ecological success of Marine Protected Areas

This chapter other than reformatting of references, has been submitted to Frontiers in Marine Science as Townsend, Ginige and Stafford, Factors affecting the ecological success of Marine Protected Areas

3.1 Introduction

Ocean ecosystems are under pressure from a variety of anthropogenic sources, notably overfishing and climate change.[190] Marine protected areas (MPAs) can be a scientifically proven and legally enforceable method to manage the marine environment,[191] and one of the key methods is recommended by the Convention of Biological Diversity (CBD), which currently has targets for 10% of the world's oceans to be protected by 2020.[192]

While there are many conservation success stories from MPAs,[193] other studies have demonstrated that poorly managed MPAs can have no ecological benefit,[194] and in many cases, ecological data can be lacking in demonstrating successful outcomes.[195] Furthermore, there is often a divide in how data is collected for MPAs, some focussing on management and governance, and some providing ecological data, but very few providing both.[196]

Edgar et al. provide a comprehensive overview of the most important factors for creating an ecologically successful MPA,[197] commonly known as the NEOLI factors

[190] A Broderick, 'Grand challenges in marine conservation and sustainable use' [2015] 2 Frontiers in Marine Science 11
[191] M Sciberras, 'Evaluating biological effectiveness of fully and partially protected marine areas' [2013] 2
[192] G Borrini-Feyerabend et al., 'Governance of Protected Areas: From understanding to action' [2012] 2 Environmental Evidence 1-31
[193] F Gell and C Roberts, 'Benefits beyond boundaries: the fishery effects of marine reserves' [2003] 18 Trends in Ecology and Evolution 448-455; M Sciberras (n191); D Gill et al., Capacity shortfalls hinder the performance of marine protected areas globally' [2017] 543 Nature 665-669; Mark Costello and Bill Ballentine (n92), Benjamin Halpern (n61)
[194] G Edgar et al. (n35) ; D Gill et al. (n193); R Stafford et al., 'An integrated evaluation of potential management processes on marine reserves in continental Ecuador based on a Bayesian belief network model' [2016] 121 Ocean & Coastal Management 60-69
[195] R Stafford et al., 'Lack of evidence that governance structures provide real ecological benefits in marine protected areas' [2018] 152 Ocean and Coastal Management 57-61; D Gill et al. (n193)
[196] R Stafford et al. (n195)
[197] G Edgar et al. (n35)

(No take, Enforced, Old, Large and Isolated). However, trends indicate that more MPAs are being designated to help meet CBD targets,[198] several of which have been very large in size, but due to their recent designation, relatively young.

There is considerable confusion about what should constitute an MPA. For example, the CBD definition suggests an MPA should be 'managed to achieve specific conservation objectives'[199]. Yet the IUCN definition suggests that MPAs should 'achieve the long-term conservation of nature with associated ecosystem services and cultural values'.[200] As such, it is unclear exactly how and to what extent, social conservation benefits should be considered as part of evaluating an MPA's success. While this study will define success solely in ecological terms (likelihood to increase biodiversity, population sizes or sizes of individuals), we also include tourism as a potential social and economic benefit, but likely ecological hindrance to the ecological success of an MPA.[201]

There are also clear potential conflicts between the 'success' factors of an MPA. For example, without more resources and staff, larger sized and isolated MPAs will be more difficult to enforce than a small MPA in full view from land. Indeed a lack of resources has been identified as a key factor in MPAs not achieving their

[198] D Tittensor et al., 'A mid-term analysis of progress toward international biodiversity targets' [2014] 346 Science 241-4; C Roberts et al., 'Marine reserves can mitigate and promote adaptation to climate change' [2017] Proceedings of the National Academy of Sciences
[199] United Nations (n30)
[200] N Dudley (n136)
[201] M Milazzo et al., 'The impact of human recreational activities in marine protected areas: what lessons should be learnt in the Mediterranean Sea?' [2002] 23 Marine Ecology 280-290; P Lopes et al., 'Fisheries, tourism, and marine protected areas: Conflicting or synergistic interactions?' [2015] 16 Ecosystem Services 333-340

potential.[202] For many MPAs, economic viability must also be considered, especially within the local community, if local fishing practices will be displaced.[203] As such, designation, governance and enforcement of MPAs is a delicate task, especially if multiple stakeholders are included in these processes.[204]

This study will re-evaluate the factors causing success of MPAs using data from MPAs around the world. We will consider the NEOLI factors, as well as tourism (see table 3) to predict the ecological success of MPAs using a Bayesian belief network.[205] We will also consider the effects of interactions between the six factors, as well as the effects on factors including fish catch and overall local economic income on the success scores of the MPAs.

Table 3 factors which can contribute to the success of MPAs

Influencing factor	Why is this factor influential and important?
Size	Size influences MPAs in achieving their targets. The bigger the MPA the more likely it will be successful in enriching biodiversity and sustainability in that area, predominantly where MPAs are established to recover from overfishing and restore and repair its coral reefs.[206]
Age	Age impacts and enhances the benefits an MPA provides.[207] The older an MPA the more likely it will be nearer to achieving its

[202] D Gill et al. (n193)
[203] P West et al., 'Parks and peoples: the social impact of protected areas' [2006] 35 Review of Anthropology 251-277; Stafford et al. (n194)
[204] E Jones et al., 'Are fisheries-dependent communities in Scotland really maritime-dependent communities?' [2014] 95 Ocean & Coastal management 254-263
[205] R Stafford et al. (n97)
[206] Benjamin Halpern (n61)
[207] Phillip Molloy et al. (n58)

	objectives. However, each MPA does differ; such as some populations may take decades to recover,[208] this could be due to the condition it was in before it was designated. Furthermore, older MPAs should have greater fish density than the younger.[209]
Tourism	Tourism is a great threat for the oceans, and cause biodiversity and sustainability to plummet. This is due to human disturbance through diving, swimming, using boats, pollution and many other activities. These undertakings effect the water quality, demolish habitats and consequently cause huge disruption to the environment.[210] Therefore, the more tourism, the more human disturbance, leading to disruption of biodiversity. Tourism can also be beneficial however, if done in the correct manner and is monitored, raising awareness and money to help enforcement in sustaining the MPA and its targets.
NTZ or fishing restrictions?	MPAs that are not NTZs can bring a lot of disturbances with them, with the several methods of fishing not only destroying habitats but extracting fish, and the crossing of boats. All of this can reduce biodiversity and deter fish from their usual routine and breeding patterns. NTZs allow for MPAs to recover quicker and more efficiently, with habitats staying intact and ocean life undisturbed, encouraging biodiversity to upsurge.
Location	An MPAs location will dramatically affect its success. Those MPAs that are isolated away from land do not face all the stressors that those closer to land do. Being isolated and at a distance prevents a lot of human disturbance such as tourism and fishing. However, this factor cannot be controlled, an MPA is an area that requires to be established to be conserved and be protected, therefore, cannot change location.
Enforcement	Without enforcement an MPA's would not be of any value, there would be no promotion of objectives. The status will become pointless and rules will not be abided by. With no enforcement MPAs will not achieve their goals and will be ineffective and will lack biodiversity.

[208] Myers et al. (n59)
[209] Phillip Molloy et al. (n58)
[210] Clevo Wilson and Clem Tisdell (n38)

3.2 Method

Twenty-seven MPAs from across the world were considered in this study, including those from developed and underdeveloped countries. These MPAs spanned a wide range of the different success factors (Figures 2 and 3), and a detailed analysis of the importance of these factors for each MPA was conducted from scientific literature and appropriate web sources (see appendix). We used a Bayesian belief network (BBN; fully described in Stafford et al[211]) to convert values allocated to each factor (as defined by consulting data in appendix 1 and discussion between all authors provided in Table 4) to an overall success score.

The Bayesian belief network model was developed by Stafford et al[212] is based on previous Bayesian belief networks (reviewed by Grover[213], 2013; see Hammond and Ellis[214] for an ecological example applied to species interactions). The model used has several important differences making the application of the networks much more intuitive for application to reciprocal interactions.

The belief network model used in this study was constructed using Microsoft Excel 2010, with the use of VBA programming to perform many of the calculations (see mpamanagement.net for copies of the spreadsheet). For each node in the network a 'prior' value between 0 and 1 is given to indicate the belief that a given node may increase or decrease [P(X i) and P(X d) respectively]. A node is only ever considered

[211] Stafford et al. (n97)
[212] ibid
[213] Jeff Grover, 'A Literature Review of Bayes' Theorem and Bayesian Belief Networks (BBN)'[2012] 9 Strategic Economic Decision-Making11-27
[214] T Hammond and J Ellis, 'A meta-assessment for elasmobranchs based on dietary data and Bayesian networks' 2002] 1(3) Ecological Indicators 197-211

as increasing or decreasing, and the probability gives a clear indication of the likelihood of this. In this belief network, the sum of the probability of a species increasing and decreasing must equal 1. The parameters of node interactions are provided in a series of interrelated matrices. Each interaction is independent of any others, and only direct effects between nodes are modelled – indirect effects are emergent properties of the

network. The belief network draws on four sets of parameters for each node interaction:

1. Probability of node b decreasing, given node a is increasing.
2. Probability of node b increasing, given node a is increasing.
3.Probability of node b increasing, given node a is decreasing.
4.Probability of node b decreasing, given node a is decreasing.

In most cases, these are highly related parameters, where parameter 2 above is equal to 1-parameter 1; parameter 3 is equal to parameter 1 and parameter 4 is equal to parameter 2. However, they do not have to follow the above rules and can be set independently if needed. Given these parameters, intermediate probabilities of each node increasing given node interactions are calculated using the following Bayesian equation:

$$\mathrm{P}\left(\mathrm{X_i}|\mathrm{Y}\right) = \left[\mathrm{P}\left(\mathrm{X_i}|\mathrm{Y_i}\right) * \mathrm{P}\left(\mathrm{Y_i}\right) + \mathrm{P}\left(\mathrm{X_i}|\mathrm{Y_d}\right) * \mathrm{P}\left(\mathrm{Y_d}\right)\right],$$

Where X is the MPA under consideration, and Y are the interacting success nodes and success scores, subscripts I and d indicate increasing or decreasing MPA success.

Where there is no knowledge of a change in node exists (i.e. the prior probability of change is 0.5) then this node is not included in the above equation (however, such inclusion might occur in the second iteration of
the model, see below for details).

At this point, no 'prior' information on node X is included in the calculation. To ensure any prior knowledge available is maintained in the network, the overall posterior probability for each species is calculated in two ways, the first ensuring that additional information on node interactions add to the certainty provided by the prior, the second will ignore prior values, if information on node interactions provide more certain information than the prior:

$$(1)\text{Post}(Xi)=P(Xi)+|1-P(Xi)|*[\sum 1-n(P(Xi)*(P(Xi|Y)-0.5))/n],$$

And

$$(2)\text{Post}(Xi)=[\sum 1-n(P(Xi|Y))]/n,$$

where n is the number of interactions with node X. The final value of Post(X_i) is given by the value displaying the most certainty (i.e. furthest in magnitude from 0.5). The model is then repeated for a second iteration, but with updated prior probabilities such that:

$$P(Xi)=\text{Post}(Xi),$$

Three iterations of the model are performed to ensure data propagate through the network fully.

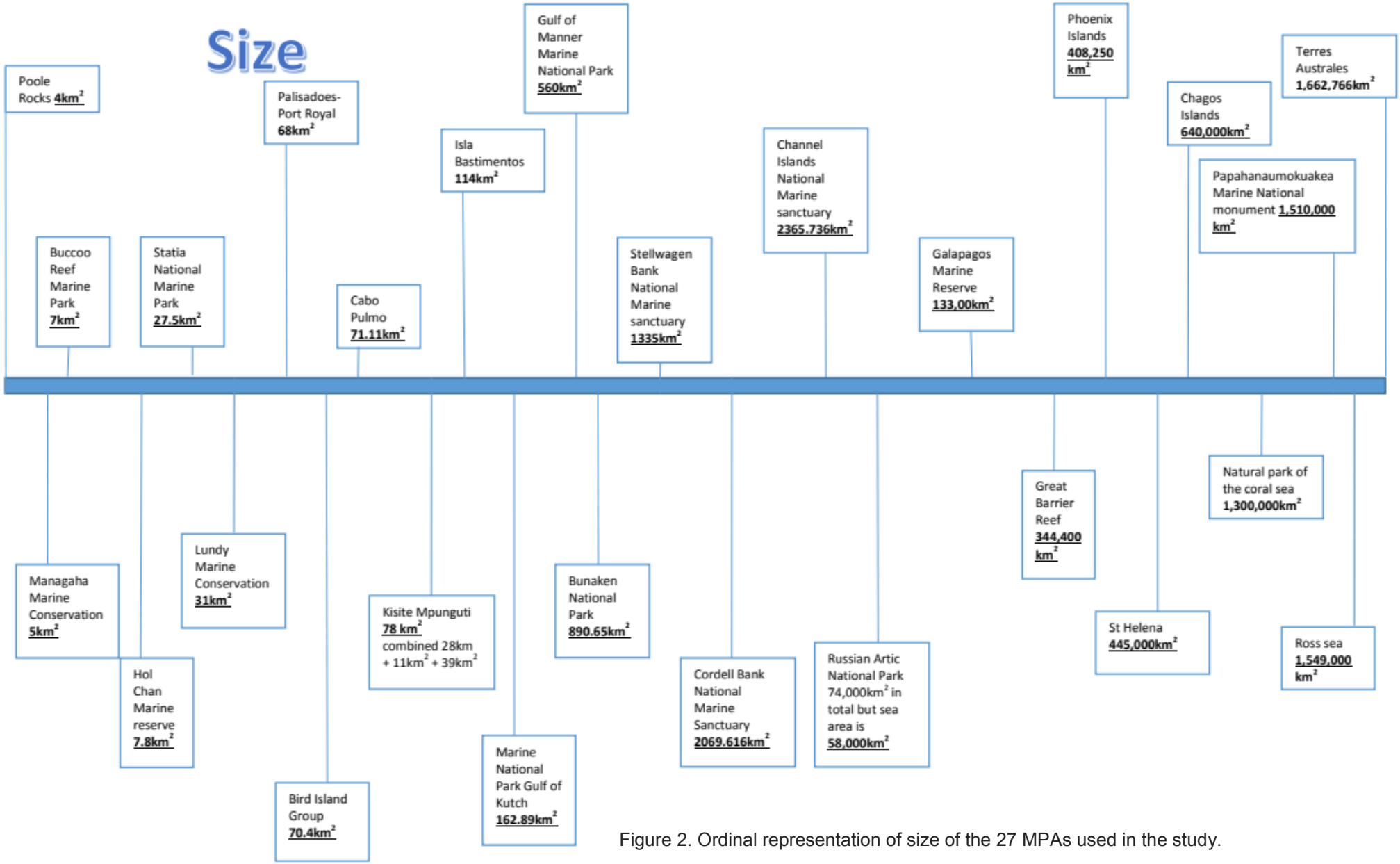
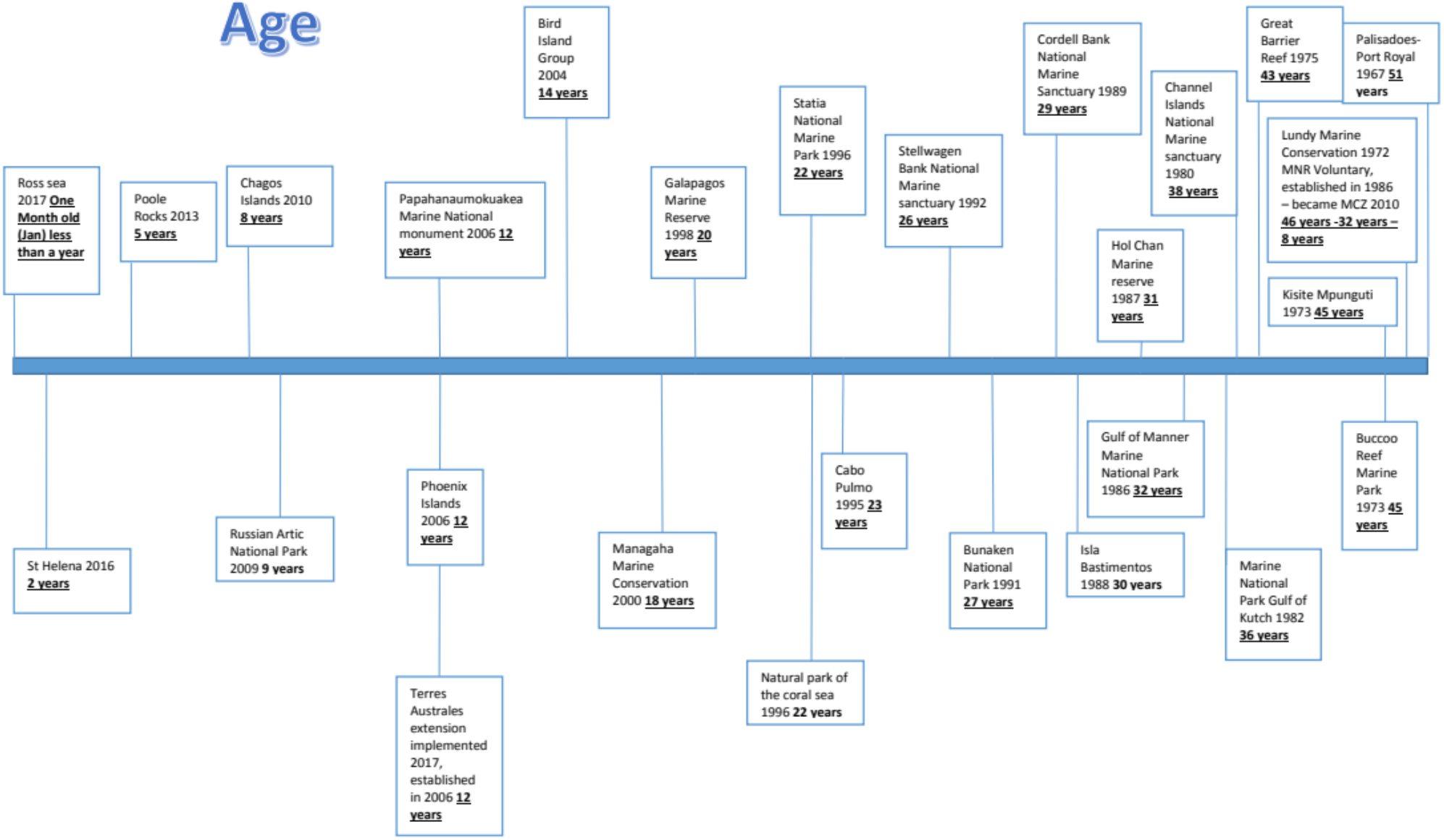


Figure 2. Ordinal representation of size of the 27 MPAs used in the study.

Figure 3. Ordinal representation of age of the 27 MPAs used in the study.


Age
Ross sea 2017 One Month old (Jan) less than a year
Poole Rocks 2013 5 years
Chagos Islands 2010 8 years
Papahanaumokuakea Marine National monument 2006 12 years
Bird Island Group 2004 14 years
Galapagos Marine Reserve 1998 20 years
Statia National Marine Park 1996 22 years
Stellwagen Bank National Marine sanctuary 1992 26 years
Cordell Bank National Marine Sanctuary 1989 29 years
Channel Islands National Marine sanctuary 1980 38 years
Great Barrier Reef 1975 43 years
Palisadoes-Port Royal 1967 51 years
Lundy Marine Conservation 1972 MNR Voluntary, established in 1986 – became MCZ 2010 46 years -32 years – 8 years
Kisite Mpunguti 1973 45 years
Hol Chan Marine reserve 1987 31 years
St Helena 2016 2 years
Russian Artic National Park 2009 9 years
Phoenix Islands 2006 12 years
Terres Australes extension implemented 2017, established in 2006 12 years
Managaha Marine Conservation 2000 18 years
Natural park of the coral sea 1996 22 years
Cabo Pulmo 1995 23 years
Bunaken National Park 1991 27 years
Isla Bastimentos 1988 30 years
Gulf of Manner Marine National Park 1986 32 years
Marine National Park Gulf of Kutch 1982 36 years
Buccoo Reef Marine Park 1973 45 years

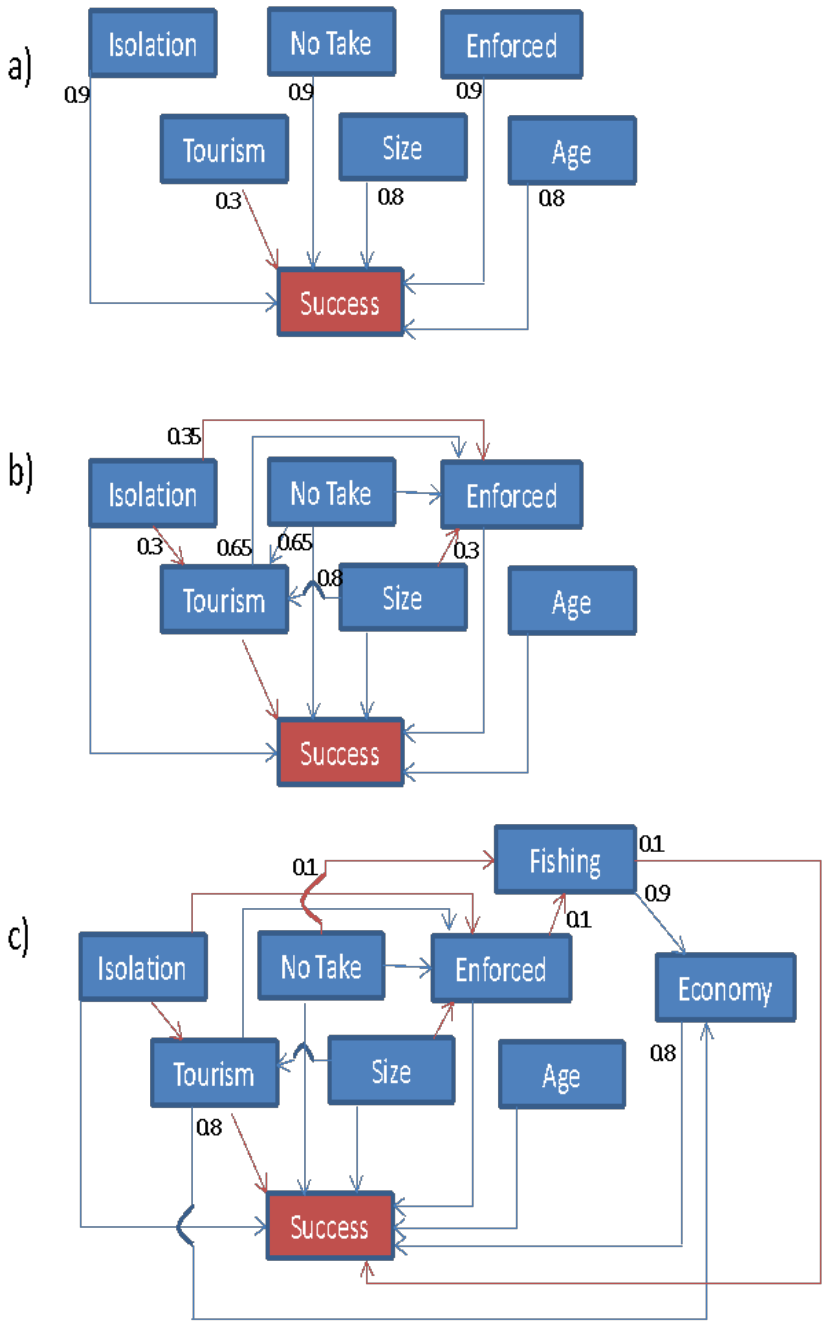


Figure 4. Diagrammatic representations of Bayesian belief networks used to determine success. Blue rectangles represent key success factors and red rectangle represents the success node in the network. Edges joining nodes indicate connections between the nodes with red indicating a negative interaction (if input node increases, it is likely that target node will decrease, and connection strength < 0.5) and blue edges indicating positive interactions (if input node increases, it is likely that target node will also increase, and connection strength > 0.5). Numbers indicate connection strengths with 0 indicating highest certainty of a negative interaction from input to target node and 1 indicating the highest. (a) Basic model, (b) considering interactions between the input nodes, (c) inclusion of factors which directly influence fishing and economic success.

3.3 Results

The predicted ecological success of MPAs varied considerably (Table 1; Figure 7) with no clear geographical trends, other than more isolated MPAs generally being more successful than those close to land (see below). The comparison of different models involving interaction between factors, or inclusion of fishing and economic factors resulted in almost no change to success scores (maximum difference of 3% from any MPA), as such, the results presented are only for the original model described in Figure 4a.

While success scores have been calculated using predictive methods, it is nevertheless useful to consider correlations between influencing factors and success to determine the importance of the effect of each factor on success. While this is a somewhat circular argument, a lack of correlation provides good evidence that the factor can in some cases be replaced or superseded by other factors to ensure (or prevent) success.

By considering magnitude of the r values of the correlations, isolation demonstrates the best fit with success, although most of the other factors (excluding age) show moderately strong correlations with r values > 0.6 (Figure 7; all are highly significant $p < 0.001$). Age shows a non-significant but negative correlation with success. There are also some significant correlations between different influencing factors, although these are mainly only of moderate strength (Figure 8).

Table 4 Input values and success for each of the MPAs considered in this study

	MPA	Success Score 1	Tourism	No take	Isolation	Size	Age	Enforcement
1.	Chagos Islands (UK territory) (Indian Ocean)	0.85	0.01	0.99	0.96	0.76	0.14	0.97
2.	The Great Barrier Reef (Australia)	0.49	0.74	0.34	0.21	0.67	0.77	0.71
3.	Papahanaumokuakea Marine National Monument (Hawaii)	0.76	0.13	0.81	0.91	0.92	0.22	0.86
4.	Galapagos Marine Reserve (Ecuador)	0.69	0.39	0.84	0.72	0.64	0.36	0.92
5.	Ross Sea Protected Area (Antarctica)	0.74	0.06	0.68	0.98	0.95	0.01	0.87
6.	Terres Australes Francaises (France)	0.74	0.09	0.58	0.98	0.98	0.22	0.81
7.	Lundy Marine Conservation zone	0.44	0.77	0.54	0.15	0.17	0.83	0.82
8.	Managaha Marine Conservation Area (Saipan)	0.42	0.22	0.99	0.12	0.06	0.32	0.39
9.	St Helena	0.38	0.18	0.10	0.18	0.73	0.04	0.62
10.	Palisadoes-Port Royal (Jamaica)	0.40	0.34	0.27	0.09	0.20	0.92	0.56
11.	Poole Rocks (England)	0.25	0.64	0.24	0.12	0.03	0.09	0.76
12.	Isla Bastimentos National Marine Park (Panama)	0.34	0.70	0.22	0.38	0.31	0.54	0.28
13.	Cabo Pulmo National Marine Park (Mexico)	0.44	0.26	0.28	0.64	0.25	0.41	0.44
14.	Kisite Mpunguti (Kenya)	0.50	0.75	0.42	0.62	0.28	0.81	0.57
15.	Gulf of Mannar Marine National Park (India)	0.31	0.68	0.24	0.29	0.36	0.58	0.08

16.	**Marine National Park, Gulf of Kutch (India)**	0.30	0.72	0.15	0.19	0.34	0.65	0.22
17.	**Bunaken National Park (off the coast of Indonesia)**	0.35	0.85	0.18	0.18	0.39	0.49	0.71
18.	**Natural Park of the coral sea New Caledonia**	0.45	0.63	0.26	0.38	0.90	0.40	0.28
19.	**Statia National Marine Park (Netherlands Antilles)**	0.44	0.43	0.52	0.41	0.14	0.40	0.70
20.	**Buccoo Reef Marine Park (Trinidad and Tabago)**	0.39	0.88	0.26	0.67	0.08	0.81	0.50
21.	**Phoenix Islands Protected Area**	0.61	0.14	0.31	0.96	0.70	0.22	0.62
22.	**Channel Islands National marine sanctuary (California)**	0.67	0.87	0.86	0.83	0.48	0.68	0.84
23.	**Cordell Bank National Marine Sanctuary (USA- Northern California)**	0.57	0.17	0.39	0.75	0.45	0.52	0.61
24.	**Stellwagen Bank National Marine Sanctuary- Massachusetts**	0.36	0.59	0.47	0.24	0.42	0.47	0.13
25.	**Bird Island Group MPA (South Africa)**	0.62	0.16	0.99	0.76	0.22	0.25	0.71
26.	**Russian Artic National Park**	0.57	0.43	0.38	0.80	0.62	0.16	0.83
27.	**Hol Chan Marine Reserve**	0.31	0.91	0.33	0.31	0.11	0.56	0.44

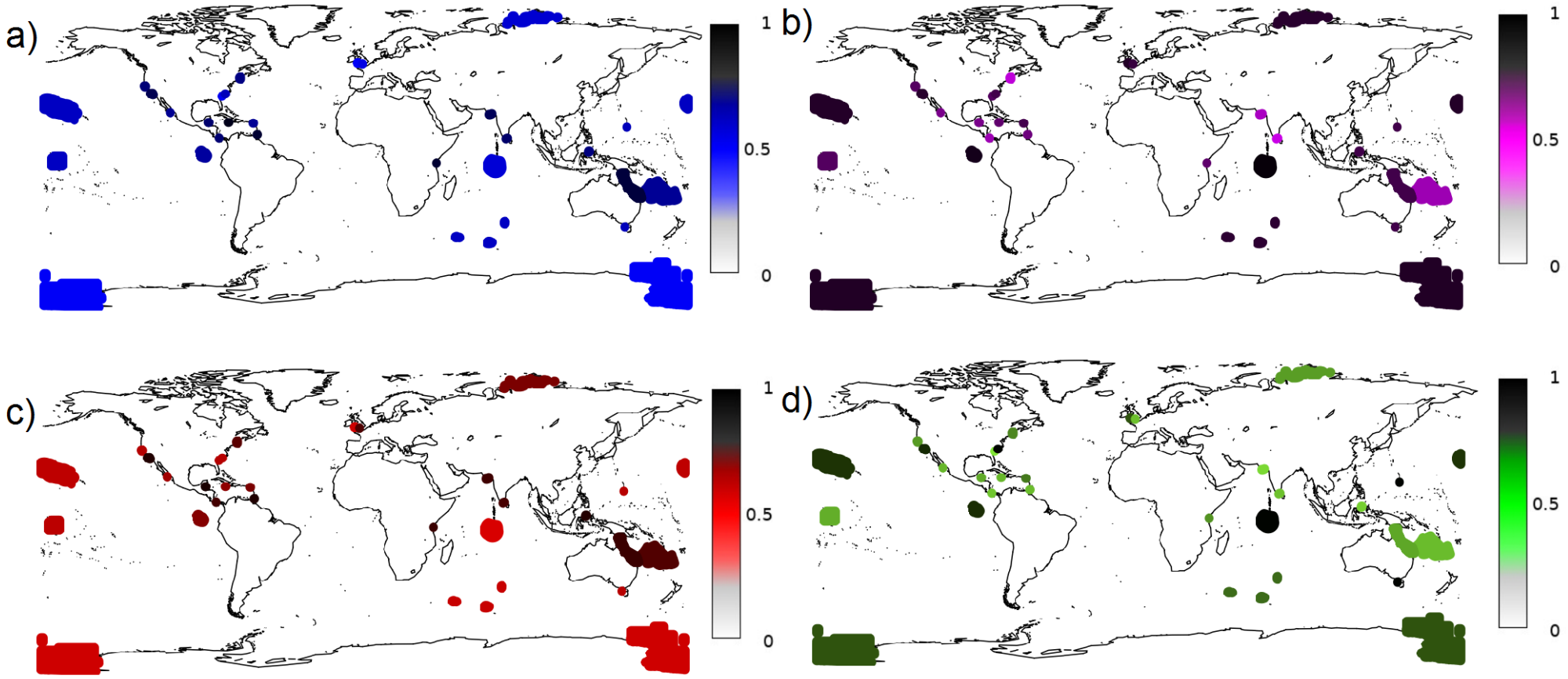


Figure 5. Locations of the MPAs used in this study. Heatmaps are colour representations of input values for the BBN for (a) Age, (b) Enforcement, (c) Tourism intensity and (d) Fishing restriction. Note, the filled colour not the border is representative of the input value.

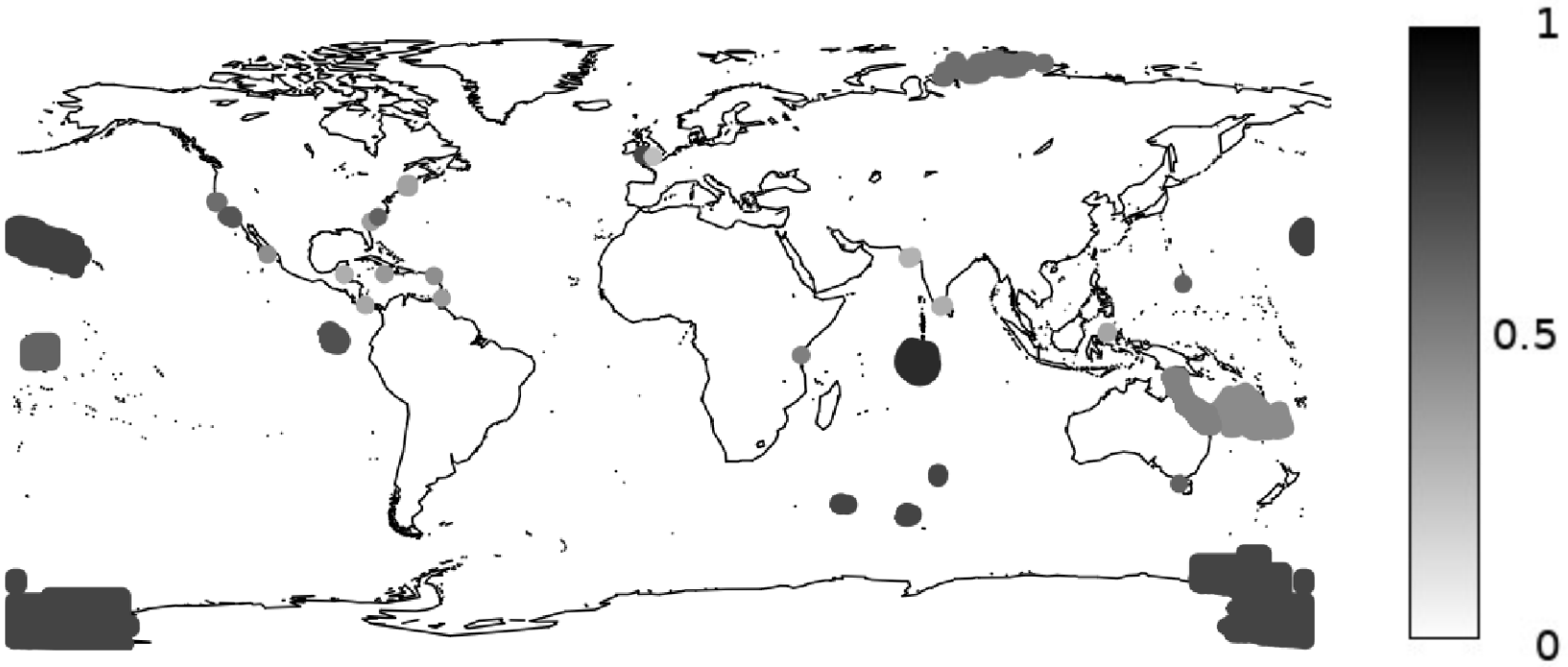


Figure 6. Locations and heat map of the success scores for the MPAs used in this study. Note, the filled colour not the border is representative of the success score.

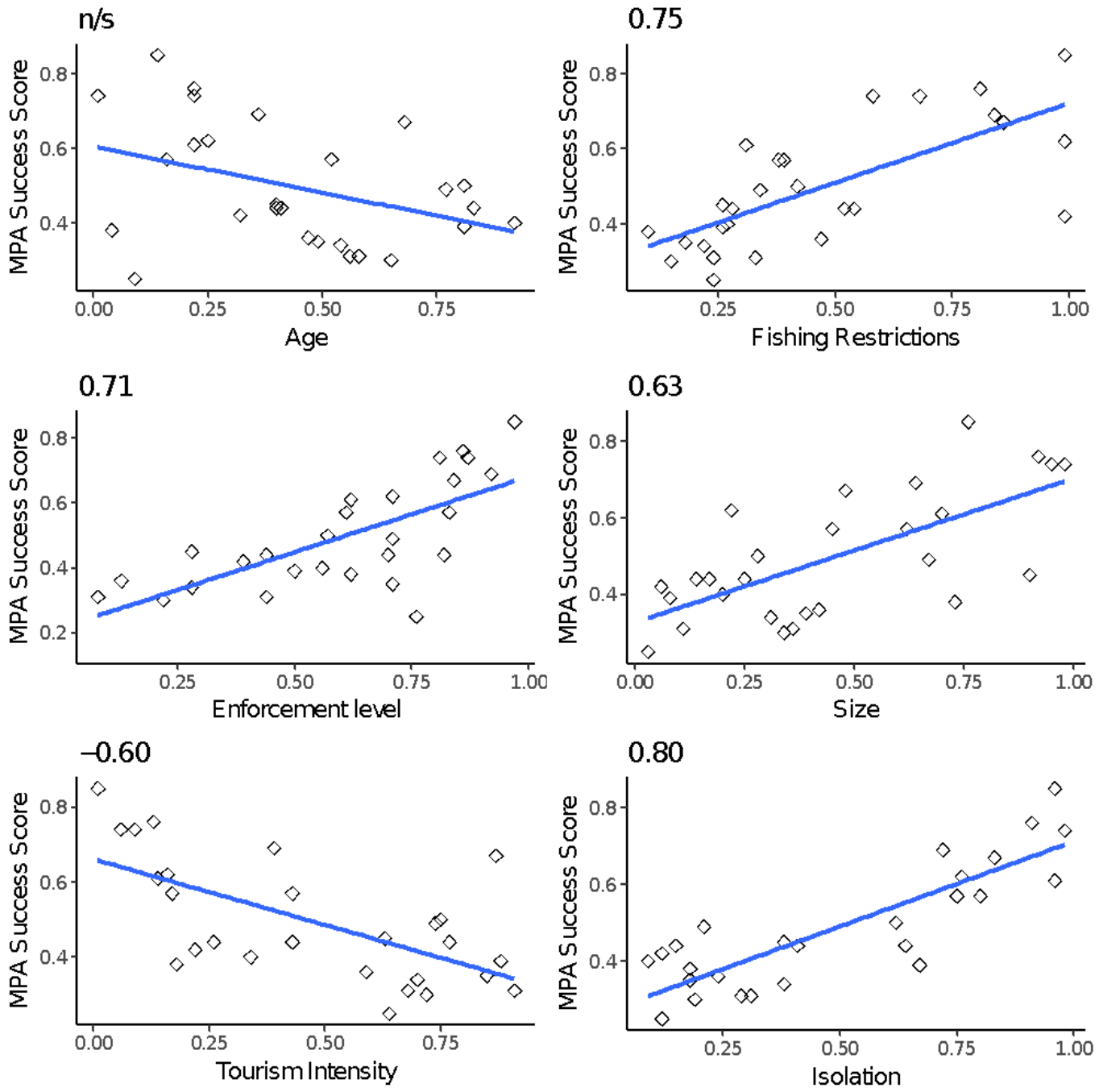


Figure 7. Relationships between each of the input factors and predicted MPA success, where correlations are significant, the r value is given.

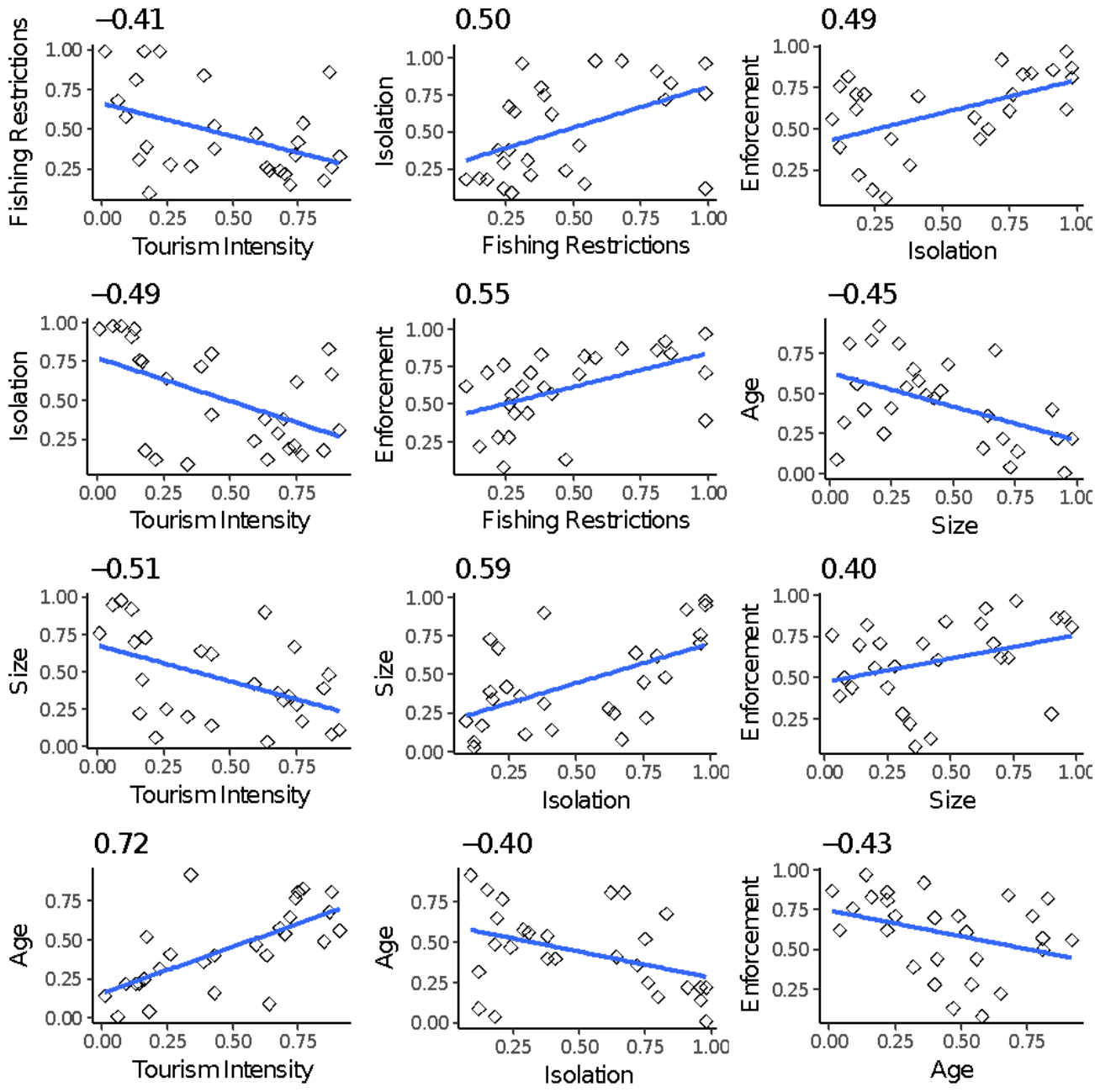


Figure 8. Relationships between different input factors which show significant correlations, where correlations are significant, the r value is given.

3.4 Discussion

The 27 MPAs studied showed a wide range of success scores, from very low to high. Examining the role of each influencing factor in success demonstrated that the current study largely agreed with that of Edgar et al.[215] for most of the factors which may determine MPA success, but that tourism also played a significant role in the current study, with increased levels of tourism causing a decline in ecological effectiveness. Age of MPA was also found to be less important than what has been previously proposed, and in this case a negative relationship between age and success was identified, despite the positive relationship specified in the BBN. Isolation was found to be the most important factor in establishing success. Establishing feedback between the factors provided little difference in success scores.

Given the use of predictive algorithms to determine success in this study, the lack of a positive relationship between age of MPA and its ecological success is unexpected, and counter too much previous work[216]; but there are studies that also support this conclusion[217]. To some extent, it may be driven by the recent trend to allocate large isolated areas as MPAs, hence the negative relationships between size and age and isolation and age found. Isolation showed the strongest relationship with success but is also positively related to many other factors (and negatively to tourism) which would indicate isolated MPAs may also fulfil many of the other roles which may be required for ecological success. The beneficial role of

[215] G Edgar et al. (n35)
[216] Myers et al. (n59); S Jennings, 'Patterns and predictions of population recovery in marine reserves' [2001] 10 Reviews in Fish Biology and Fisheries 209-231; Phillip Molloy et al. (n58); G Edgar et al. (n35)
[217] B Halpern and R Warner, 'Marine reserves have rapid and lasting effects' [2002] 5 Ecology Letters 361-366

isolation is largely supported by recent studies on the role of MPAs in areas of high and low human impact, where the ecological success of the MPA, especially in terms of predator biomass, was higher in areas far from human impact.[218]

Creating isolated, offshore MPAs is a controversial topic, however, with many people questioning whether they provide real ecological benefit, or simply just are a mechanism to meet 2020 targets[219]. Questions have been raised as to how much benefit the MPAs really provide, as factors such as fishing pressure can be relatively low, or even absent, in some areas recently designated as offshore MPAs.[220] Indeed, Cinner at al.[221] also show that although offshore MPAs provide the highest levels of fish, and especially predator biomass, it is non-isolated MPAs that are close to human activity which provide the greatest improvement in fish stocks when compared to similar reference areas.

Large, isolated MPAs however, if well enforced, are useful in preventing expansion of further offshore fishing into the high seas, and in the tropics, have seemed to create coral reef systems more resilient to climate change and less prone to diseases than other areas.[222] They can also be relatively simple to designate when

[218] J Cinner et al. (n73)
[219] D Tittensor et al. (n198); E Sala et al., 'Assessing real progress towards effective ocean protection' [2018] 91 (1) Marine Policy 11-13
[220] V Gigilo et al., 'Large and remote marine protected areas in the South Atlantic Ocean are flawed and raise concerns: Comments on Soares and Lucas' [2018] 96 Marine Policy 13-17; Luiz Rocha, 'Bigger Is Not Better for Ocean Conservation' (*The New York Times*, 20 March 2018)<https://www.nytimes.com/2018/03/20/opinion/environment-ocean-conservation.html> accessed 7 May 2018
[221] J Cinner et al. (n73)
[222] E McLeod et al., 'Designing marine protected area networks to address the impacts of climate change' [2009] 7 Frontiers in Ecology and the Environment 362-370; P Mumby et al., 'reserve design for uncertain responses of coral reefs to climate change' [2011] 14(2) Ecology letters 132-140; C Sheppard et al., 'Reefs and islands of the Chagos Archipelago,

in a single nation's waters (see below), perhaps because of the lack of commercial fishing in the area, and the economic inefficiency of fishing in these isolated areas.[223] Indeed, the issues of establishing no-take zone MPAs in coastal waters can be difficult, due to the reduction in fish yield which can occur, and as such, many non-isolated MPAs are multiuse.[224] Encouraging tourism is often seen as a way of offsetting loss of fishing income,[225] yet can have detrimental effects on the ecological efficiency of the MPA. As such, while isolated MPAs may be the most ecologically beneficial, research on how to balance effective ecological protection alongside fishing income and less harmful measures of tourism are also needed in coastal areas.[226]

The results from this study predict that large, isolated, well enforced, no-take MPAs, which limit tourist numbers, and damage, provide the greatest ecological benefits. However, it is viewed by many that MPAs have been recently designated to meet CBD targets. This study confirms the view that to ensure for the best possible protection for the marine environment, we will require more large and isolated MPAs to be designated. For this to happen we need to designate outside of national jurisdictions. However, at present, only one MPA exists outside of national jurisdiction waters. Further study on the legal and policy mechanisms to both create and enforce MPAs which cross, or fall outside national boundaries is clearly needed.

Indian Ocean: why it is the world's largest no-take marine protected area' [2012] 22 Aquatic Conservation 232-261

[223] E Sala et al., 'The economics of fishing the high seas' [2018] 4(6) Science Advances

[224] E Jones et al. (n204)

[225] E Oracion et al., 'Marine protected areas for whom? Fisheries, tourism, and solidarity in a Philippine community' [2005] 48(3-6) Ocean & Coastal management 393-410; K Babu (n40); Stafford et al. (n194)

[226] Stafford et al. (n194)

This thesis has reviewed ecological, social and legal issues around the implementation of MPAs. Through a predictive modelling approach, I have largely supported the work of previous studies (such as Edgar et al[227]) in identifying the importance of different elements or factors which influence an MPA's success; although my results also show the importance of reducing tourist inflicted damage and the limited importance of age of MPA in establishing the ecological success of an MPA.

Fishing, albeit disruptive, may not be the most harmful action to the marine environment; it is the methods that are used which can cause the most impairment,[228] damaging marine habitats, causing species to have no place to live, and therefore depleting and dying out.[229] However, some societies and cultures rely on fishing to make a living, for cultural reasons and because it is a cheap and protein rich food source. These pressures can cause conflict when trying to implement conservation measures.[230]

Looking at the key influencing factors for ecologically successful MPAs in the previous chapter, an MPA should be isolated to help it maximise and determine it being successful in attaining biodiversity and effectiveness. Isolation proved to be the most important factor from the BBN results, and as such, it is promising to see isolated MPAs being recently established in the previous few years. However, many

[227] G Edgar et al. (n35)
[228] Pauly Daniel et al. (n85)
[229] Oceana, 'Mounting evidence shows Danish sand dredging destroys cod and plaice habitat in the Sound' (n12)
[230] WWF, 'Overfishing' (n10)

of these recent MPAs may not have had much fishing effort initially, and the designation may add little to their effectiveness. When an MPA is isolated it is often too far away for actives such as tourism and fishing, automatically making more effective than those closer to land. It could also be that we are creating large and isolated MPAs to portray the idea of environmental awareness and to meet to 2020 targets. [231] However, it could just be that we acting proactively instead of reactively to the damage that may occur in the future, ensuring that our present pristine ocean areas are maintained, and abundant in biodiversity, avoiding impairment completely.

Although the BBN results displayed isolation as being the most influencing factor, without enforcement and management, isolated MPAs may not be effective. Without legislation MPAs would not be designated, and therefore, be non-existent. For the influencing factors to be beneficially effective on an MPA in enhancing biodiversity and overall marine sustainability, the legislation and management behind it plays a highly significant role. Without strong management and standardised designation, enforcement of factors could be lacking, which would cause MPAs to be inadequate.

One of the key questions now to consider is ‘how are we going to adopt large MPAs?’ with several of the world’s biggest MPAs being established in the past three years, we need to consider that the new MPAs designated will cover multiple national jurisdictions or be in the high seas.[232] The next best step could be to have an international meeting where this issue is discussed, and how we are going to effectively manage these MPAs, tabled as main focus. UNCLOS has not been able

[231] E Sala et al. (n223)
[232] High seas alliance, 'Treaty Tracker' (*High Seas Alliance*, 4 September 2018) <http://highseasalliance.org/treatytracker/> accessed 5 September 2018

to factor in national state policies and law, and can only regulate high seas but even that it is weak. There is a need for a greater agreement. At the time of writing this, there are discussions going on with the UN in regards to this matter.[233] However considerable resistance from large nations such as the US, Japan and Russia, may cause the issue to be unsolvable until these influential nations provide leadership and support.

An elegant solution to ensure minimal tourist and fishing damage, is to create long lasting and well enforced MPAs would be to introduce the ISO 14001 and apply it to marine environments, specifically MPAs, with the influence of UNCLOS and targets of CBD and COP this could be the ground-breaking standardisation we need. It will ensure that our MPAs are managed sustainably, thus promoting greater biodiversity, reaching their targets, instead at present constantly postponing them to a future date. Once we have an effective system in place with clear guidelines, it will allow a real difference in the way MPAs are viewed, and how long it takes for their targets to be met will considerably change for the better.

From an international view, on how we can manage MPAs, If we adopt the ISO 14001 as a standard, it would be sufficient due to needing to fit minimum standards. The ISO 14001 caters to majority of the influencing factors, instigating for overall effective MPA enhancement. MPAs would need a minimum enforcement standard behind them, giving them a backbone and structure to help enforce and manage them effectively. The ISO 14001 however, provides not only minimum standards, but is a work in progress, with multiple improvement goals over time. This not only

[233] ibid

promotes establishment of long-term MPAs, but means the older an MPA the more efficient it would be. This can be beneficial as MPAs would be constantly improving and therefore, not taking any steps backwards. Fishing and tourism would need to meet certain standards to be accredited, as these are services that an MPA provides.[234] As such, again, the levels of responsible tourism and fishing should continually improve towards a better system. Enforcement would also need to be improved and adapted in order to meet the standards set. This would help to allow for MPA management to have an internationally recognised management system, rather than each national jurisdiction having their own. This would mean MPAs outside of national jurisdiction, or those that cross boarders to be enforced and managed effectively. We could then focus on the MPA itself, and what management it needs to be most effective in achieving its goals. Unlike the present, where focus is surrounding the confusion management is currently bringing, taking away the true focus and meaning of MPAs.

The world is now viewing MPAs as a key tool to help reverse damage and maintain the pristine habitats and biodiversity in certain areas of the ocean, therefore MPA numbers are going to grow with more and more being designated. We are still learning what makes a good MPA and improving and working on the ones currently established. Thus meaning MPA effectiveness, and biodiversity success should be reviewed again to see where improvements can occur, so we can help to sustain and repair our oceans. If we did not have a mechanism such as ISO 14001 added to the enforcement system, to constantly re-evaluate MPA progress, MPAs would just be lines on a map; is this what we really want for our marine environment?

[234] Myles Thompson et al. (n150)

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Appendix 1, summary of literature review on the 27 marine protected areas.

MPA	Size	Age	NTZ?	Tourism/ Recreational activities?	Isolation	Effective Enforcement	Key Other Factors (e.g. state when designated)
Chagos islands (UK territory) (Indian Ocean)	640,000 km^2	**01.04.2010 (7 nearly 8)** Islanders deported in 1971	Yes. *Chagossians use to fish for food source – stopped and deported. *All is NTZ.	No. ☐ Not a tourist destination. ☐ Access is restricted – to access you need a permit.	Yes. Approximately 736km from closest country (Maldives). *Central of Indian Ocean. *1,500km – tip of Indian. *3,400km- East African *3,000km – West Indonesia	Yes, very effective, deported all local inhabitants (Chagossians). No one now lives there –only military base. – Court held decision.	*Unspoiled, rich, biodiverse coral reefs. *islanders deported 1971- only 1,500, was this necessary? Yet give an inch take a mile = tourism. Fishing etc. = destroyed.
The Great Barrier Reef (Australia)	344,400 km^2	**1975 (42/43)** Great Barrier Reef Marine Park Act 1975	Partially (110,094.27 km^2)	Yes. Very popular. Important economic activity for the region, generating billion dollars a year.	No. *Off the coast of Queensland (North-East Australia).	Large part of the reef is protected by the GBR Marine park, limiting human use such as fishing and tourism – BUT still allowed in parts.	Other pressures include: *Coral Bleaching *Climate Change *Surface run off
Papahanaumokuakea Marine National	1,510,000 km^2 *one of the	**Established in 2006** (362,598km^2) Obama quadrupled	Yes - for commercial and mining.	Limited. Only to midway atoll.	Ocean surrounds uninhabited	Argues that "there is insufficient enforcement on the waters to control them" (foreign fishing vessels) – Shane Yoshimoto.	Quarter of the creatures living there are found

Monument (Hawaii) (Largest implemented MPA)	world's largest MPAs	this in 2016 (August)	Recreational is allowed with permit. (Hawaii argues only ever longlines, no trawlers- so not much difference).	Monument receives strict conservation with exception for limited tourism.	north western islands of Hawaii.	Matt Rand –"Long lines have an environmental impact… we need this area off limits. https://www.papahanaumokuakea.gov/management/mp_faq.html	no-where else in the world.
Galapagos Marine Reserve (Ecuador)	133,000 km^2 Surrounds islands	**1998** (19/20) (In 1959 government of Ecuador created Galapagos national park) 1970s human activity caused waters to suffer	Partially *commercial fishing allowed in some areas. *Regularly monitored by fishermen and scientists (number, health of fish and crustacean population).	Partially/limited. Mare than 100,000 people visit per year. Some areas allow sport, fishing and snorkelling etc. however, in these areas removal of plants and animals is prohibited.	No-ish. Surrounds islands. But also 1,000km (600 miles) from Ecuador's coast.	Scientists have conducted surveys for more than a century at the Galapagos. *train locals sustainable fishing. *monitored regularly. *to ensure tourists observe and obey regulations, uses satellite based GIS technology to monitor activities.	* Rich biodiversity *Warm and cold current mix. *nutrient rich waters. *Charles Darwin wrote about in mid 1800s.
Ross Sea Protected area (Antarctica)	1,549,000 km^2 second largest MPA in the world	**2016** Designated in 2016. Enforced December 2017.	Yes (72%) – but some tooth fishing is expected to proceed in a specifically designated area. (Antarctic tooth fish – a predatory fish that is sold as a highly prized Chilean Seabass).	Not really *Highly remote protected area. *ENRIC SALA "One of the places where humans are only visitors and large animals rule".	Yes. *Highly remote and pristine stretch of ocean. *Escaped heavy fishing and shipping pressures due to this. *Rising prices and low fuel cost has made fishermen consider though.	To improve awareness and management a team of technology experts, mapping specialists, and lawyers partnered with private enterprises and the U.S. National Oceanic and Atmospheric administration to make it easier and more affordable for marine protected areas to live up to their names.	*16,000 species expected to live in Ross Sea. *Rich Biodiversity.

Terres Australes Francaises (France)	1,662,766 km^2 The largest MPA in the world.	**03.10.2006** created nature reserve **12.12.2016 Extension** (due to be implemented in December 2017)	Yes – 128,000 $^{km2\ of}$ strict protected zone -in the marine area all waste discharge and the extraction of natural resources, including fishing is prohibited.	128,000 $^{km2\ of}$ strict protected zone - On land, all access and human activity is prohibited, with the exception of activities authorised trough derogation granted by Nature reserve manager.	Very isolated. Thousands of km from other land (Australia, Madagascar or South Africa). No permanent inhabitants and are visited only by researchers studying the native fauna.	The management plan of the Nature reserve is drawn up in close collaboration with the scientific community, it constitutes a true roadmap, ensuring the conservation of this natural heritage. Plan includes actions to improve knowledge on marine species and ecosystems, to implement National Action Plans.	These national action plans are for the protection of threatened species, to strengthen biosecurity measures, to fight against invasive alien species, to reduce the impact of human activity, to manage sustainable fisheries, to set up an observatory of biodiversity or to organise awareness campaigns.
Lundy Marine Conservation zone	31 km^2	**1972** (MNR) (Voluntary) **1986** MNR established. In January **2010** became an MCZ.	Yes - in 2003 3.3lkm^2 designated to be a no-take zone.	Yes. *Cliff climbing *Diving/Snorkelling. *Wildlife watching.	19km off the North Devon Coast.	Illegal to fish, scallop or harvest in area. NTZ is monitored regularly after in 2003 to 2008 a five-year long survey was conducted.	127% increase in the abundance size of lobsters. Meeting its objectives. *Also promoted biodiversity outside MPA.
Managaha Marine Conservation Area (Saipan)	5km^2	**2000 (17 years)**	Yes all 5km^2 is no-take.	Snorkelling allowed but no stepping on coral, fishing, feeding fish, littering and collecting of shells and coral is allowed.	The islands inhabit approximately 69,000 and welcome hundreds of tourists annually.	-Coral watch (a non-profit organisation) monitor area.	
St Helena	445,000 km^2	**September 2016**	No. Licence fishing only is allowed however, with conditions. St Helena's	Yes. But there is a marine tourism accreditation scheme – must attend various courses with local environmental	Approximately 4,500 inhabitants. Tourism set to increase as of October 14th 2017	The UK pledged £20million for the years (Sept) 2016-2020, to support the implementation, management, surveillance and crucially the enforcement.	Category VI = Sustainable use. A new fisheries ordinance and regulations, and a new fisheries licensing policy is

			fishing industry targets tuna – catches are recorded. Tuna tagging scheme also underway.	authorities. Frequent spot checks.	can arrive by plane. 2,605km approx. from Angola (Africa).		being drafted, and implemented within a few months of September 2016. (Should be in place now).
Palisadoes-Port Royal (Jamaica)	68 km^2 approx.	**Sept 1998 under NRCA 08.05.1967** Was declared under the Beach Control Act	No. Trying to ban dynamite fishing. Aims to improve economic opportunities for fishers through management rather than exclusion.	Yes. But only in the allowed zones. All activities will be examined and evaluated for approval. Low impact allowed.	Surrounds port *encompasses both marine and terrestrial areas	Effective 'zoning plan' expected to reduce damage, boost specimen numbers, increase abundance of fish, and boost species numbers. (Zoning 2014-2019)	World's 7th largest natural harbour. -no removal or disturbance of physical or biological features/specimen or habitat. -no erection of permanent structures. -No dumping or burning.
Poole Rocks (England)	4km^2 Approx	**November 2013 (4 years)**	No – supports commercial fishing, particularly for crab and common lobster.	Yes – these reefs support recreational activities such as diving and angling.	No –it's an inshore site. It lies to the East of the entrance of Poole Harbour. Approx 2-21/2 km to the East of the beach front of sandbanks.	*many activities within the marine environment are regulated through marine licences. *EU Legislation – fishing. *National statutory instruments. *By laws. *Self-imposed agreements. -Management of sites currently being prioritised.	The site protects an area of rocky outcrops within the sediment dominated Poole Bay.
Isla Bastimentos National Marine Park (Panama)	114km^2 approx.	**1988 (Set up 29 years)**	No –but limited? Population depends on fishing for consumption and income.	Yes. Boating and snorkelling tours are available, as well as trails through the terrestrial part. The need for careful management of	No- There is a small airport. But just off the coast of Panama and Costa Rica.	Long-term survivorship of this recovering population will depend on the social, economic and environmental sustainability of the region.	The park provides developmental and adult foraging habitat, serves as a mating area, and offers well-protected beaches for nesting.

				ecotourism is becoming evident at the Bastimentos Park, where daytime recreational use has increased dramatically.	Population of 10,000.		
Cabo Pulmo National Marine Park (Mexico)	71.11km^2	**June 1995 (22 years)**	**Past 10 years the park's endured pressures from commercial fishing. In a region where the locals live on the seafood they catch by hand, enforcing a ban on fishing is a challenge. But, both Mexican and American residents want to protect the marine environment and promoting sustainable fishing practices.**	Environmentally responsible tourism, consisting of visiting the national park without altering the natural environment and with the objective of enjoying or studying the natural and/or cultural attractions of the area, by means of a method that promotes conservation and sustainable development, which constitutes active participation of and socioeconomic benefit to the local population.	**60 miles north of Baja's tourism epicentre, Los Cabos. Surrounded by undeveloped desert.** Can drive from Mexico airport – Los Cabos (90 minutes) so inhabitants very close by. (113 residents).	**Although conservation efforts are headed in the right direction, federal enforcement and financial aid remains scarce and the quest to protect Cabo Pulmo National Park falls heavy on the shoulders of the local community, just 113 residents.**	**The Cabo Pulmo Reef has eight fingers of hard coral reef, providing a safe haven for many of the 800 species of marine animals found throughout the Sea of Cortez. The rich biodiversity of the area is unparalleled and as a result was targeted by overzealous sport and commercial fisherman during the 80's. Abusive over fishing led to a tremendous decline in fish population.**

Kisite Mpunguti (Kenya)	39km^2 Kisite park: 28km^2 Mpunguti Reserve 11km^2	Established in **1973**, under the Wildlife (Conservation and Management) Act Cap 376 of the Laws of Kenya by legal notice no. 216. The Mpunguti and Kisite, jointly gained its status as a Marine Reserve and Park in 1978.	Yes. The Park was a fishing ground for the local communities, there was hostilities in establishing the MPA. Fishing is not allowed in the marine park but deep sea fishing lovers can travel further out into to the Pemba channel to catch large barracudas, marlin, sailfish and kingfish.	Yes. Snorkelling, bird watching, sunbathing, camping and diving are popular. The park is open all year around.	It lies in the coral gardens south of Wasini Island and encompasses three small coral rag forest islands, each with considerable areas of fringing reef. Kwale District, Coast Province. The Marine Park lies 11 km off the Kenyan Coast (at Shimoni) and 8 km north of the Tanzanian boarder. 547km from Nairobi, 90 km from Mombasa.	The park was managed by Wildlife Conservation and Management Department of Ministry of Tourism and Wildlife until 1989, when the KWS was established and took over its management.	Established to protect the scenic islands and special habitats of a wide range of endemic marine animals and breeding migratory birds.
Gulf of Mannar Marine National Park (India)	560 km² surrounded by a 10 km wide, 160 km long buffer zone	The entire area from Pamban to Tuticorin Barrier Reef was initially declared a Marine National Park in 1986. In 1989, the National Park was given the status of a Biosphere Reserve.	No. Though fishing is not restricted in the reserve area, fishermen cannot venture into the protected national park area. Over	Yes. Glass bottom boat trips, snorkelling and bird watching all popular.	There are about 125 villages on the fringes of the park and only three of the islands are inhabited. T he park is always open	The Gulf of Mannar Biosphere Reserve Trust (GOMBRT) has taken up the process of demarcating the marine park area by floating buoys surrounding the area.	It has a 365 km long coastline extending from Rameswaram in the north to Kanyakumari in the south, which constitutes a part of four districts: Ramanathapuram, Tuticorin,

			35,000 of the 100,000 people living in the Reserve's buffer zone make their living from fishing, seaweed collecting, or other marine-based activity.		There is a railway station at Mandapam, Rameswaram and at Tuticorin. There are regular buses to this park. The nearest airport is in Madurai, about 150 kms from the Park.		Tirunelveli and Kanyakumari of Tamil Nadu.
Marine National Park, Gulf of Kutch (India)	162.89 km^2	Established in 1982 under the provisions of the Wildlife Protection Act, 1972 of India.	No. Sea trade and fishing were important traditional occupations. Fishing, has been very negatively affected by environmental pollution, and competition from large fishing vessels.	There are two guest houses in the park with 60 beds. The species diversity in the MNPS areas is being leveraged to promote tourism. In 2006- 07, about 7,000 tourists visited the Pirotan island, which is rich with fringing coral reefs and mangroves.	The nearest town to the park is in Jamnagar which is about 7 kms. The railway station is in this town. The journey from Jamnagar to these islands is by ferry only. Boats are available from Bedi and Nava ports. The tides are to be checked and information is available at these ports. Jamnagar is	Has a management plan, but it is dated. However, the plan has done little to protect the region from the depredations of industrialization. The reasons include overlapping jurisdiction of various government regulatory bodies, and the absence of clear physical and legal boundaries. The lack of a political opposition strong enough to take on the single-minded drive towards industrialization in Gujarat is another reason.	The 1994 MNPS management plan had proposed that Pirotan be designated a Zone 1A Area, that is, an area under the highest protection within the MNPS, closed to all activity except scientific research, visits of pirs (sacred places) by fishers, and afforestation. However, zoning was never implemented, and, instead, the island was opened to tourism.

					92 kms.		
Bunaken National Park (off the coast of Indonesia)	890.65 km² Overall, Bunaken is covers an area of 75,265 hectares with five islands within, which is the island of Manado Tua, Bunaken Island, Siladen Island, Mantehage Island and the branch of it, Naen Island.	Established in 1991. One of Indonesia's first.	Despite its national park status and significant funding, the park has suffered a slow, continuous degradation due to a number of threats including coral mining, anchor damage, blast fishing, cyanide fishing, diving, and trash. The World Wildlife Fund provides conservation support in the National Park as part of the Sulu Sulawesi Marine Eco-Region Action Plan. This includes participatory enforcement and patrol, which resulted in	Yes. Human activity still needs to carry on however and this is recognised by allowing Support Zones where economic activities may take place such as traditional fishing, restricted mangrove harvesting and seaweed culture under license. Similar zones on land allow for housing, community development, and efficient agricultural practices with controlled use of pesticides and herbicides and commercial fertilisers. Tourism is strongly developed, with accommodation ranging from backpacker cottages to 5 star resorts. Between 2003 and 2006 the number of visitors ranged from 32,000 to 39,000 of	The area is densely populated, with 22 villages inside the park comprising about 35,000 people. Most locals work as fishermen or farmers cultivating coconut, sweet potato, banana or seaweed for export, while a small number are employed in tourism as dive guides, boat operators and cottage staff.	In 1994 a management plan was created to put the structures and systems in place to achieve the objectives for which the park was created, including 4 main branches: *Zonation and Enforcement - dividing the park into sections and enforcing the rules governing each section. *Communication with and education of the public living inside and outside park boundaries. *Scientific research to develop, evaluate and improve natural resource use policies in Bunaken National Park and to evaluate the impacts in the park caused by development activities from outside. *Co-ordinating activities of government and non-governmental organisations, police, educational and research institutions, mass media, local communities, and the private sector (such as dive operators) to enhance management activities in the park.	Heavy fines and potentially long jail sentences await those who breach the most stringent rules governing activities in Bunaken. For example: in parts of the Nature Conservation Zones activities such as fishing or tree cutting can be punishable by a maximum jail term of 10 years and a fine of up to 2 million rupiahs. All proceeds from sales of the entrance tags and tickets are managed by the Bunaken National Park Management Advisory Board. The BNPMAB will utilise these funds to finance a number of high priority conservation programmes in the park. These programmes include patrols and enforcement to abolish destructive fishing

			significant reduction of blast fishing.	which 8,000-10,000 were international visitors for each year.			practices such as blast and cyanide fishing, village improvement programs within the park, collection and disposal of plastic and other wastes entering the park's waters, marine conservation education of both village children and adults, and reef and mangrove rehabilitation.
Natural Park of the coral sea New Caledonia	1,300,000 km^2 (3 times larger than the French mainland waters). Now one of the largest protected marine areas in the world. Its creation increases the protected areas from 4% to 16 % of the waters under French jurisdiction.	Conservation International has had a presence in New Caledonia since 1996 First announced in August of 2012 in Rarotonga at the Pacific Islands Forum, formal establishment was made by legislative decree in April 2014.	The park's ecosystems generate around 2,500-3,000 tons of fish each year, providing food to New Caledonia's quarter of a million people and an economic driver for the territory's sustainable economy.	Eco-tourism provides a potential alternative economic source away from nickel mining. The lagoon is critically important to local people because of its artisanal fishing, natural products, ecotourism opportunities and coastal protection role. CI is advising the government on how their Marine Park can reach international standards. This	1,210 km from Australia. New Caledonia has 250,000 people who depend on healthy ecosystems for their fresh water, food and livelihood. The Natural Park of the Coral Sea covers all of New Caledonia's Exclusive Economic Zone (EEZ), the marine waters	"New Caledonia, however, has no navy of its own and relies on a handful of French ships to patrol an area twice the size of Texas and three times the size of Germany. What, in the end, is the meaning of its marine sanctuary if it cannot police it?" According to Conservation International (CI), "The new law brings under careful management"	Renowned for its exceptional rich biodiverse reefs. Boasts one of the largest lagoons in New Caledonia which is 24,000km^2 and provides daily fish for locals. The park aims to protect the marine environment, to maintain services rendered to man by the different ecosystems present in its scope and to contribute to sustainable development of maritime activities.

				includes building governance around cruisers and yachting tourism, fisheries and deep sea mining, and providing expertise and recommendations for marine spatial planning.	extending 12 to 200 nautical miles from its coasts.		
Statia National Marine Park (Netherlands Antilles)	27.5 km^2 extending from high water mark to 30m depth encompassing the entire coast.	Established in 1996	Within the Marine Park, there are two actively managed reserves where anchoring and fishing are not permitted in order to protect pristine coral reef.	The area is frequently accessed for snorkeling and yachting but is well monitored and protected from harm. Tourism is encouraged only to educate the public about the importance of marine conservation.	Encompasses entire coast of St Eustatius (one of the Netherlands owned Antilles islands in the Caribbean). The Island is inhabited (3000 – 4000 people) and the park is fairly accessible by the public.	Within the Marine Park, there are two marine reserves (the Northern and Southern Reserves). No fishing or anchoring is allowed in these areas in order to protect pristine coral reefs. The majority of the coral reef area around Statia is contained within the Reserves. Regular patrolling and enforcement of park laws and regulations takes place.	Throughout both Reserves, dive moorings are maintained to prevent people from anchoring, while still allowing them the opportunity to enjoy the unique experience of diving on a reef. The Reserves were set up to conserve marine biodiversity, restore dwindling fish stocks, promote sustainable tourism, and safeguard the marine ecosystem. The coral reefs boast a high biodiversity. 100% cover (with over 43% coral and 15% sponges). A wide

							array of tropical reef creatures resides in and around these reefs.
Buccoo Reef Marine Park (Trinidad and Tobago)	Tobago's largest reef system. The park spans a 7km^2 area.	Designated a restricted area under the Marine Areas Preservation and Enhancement Act in 1973.	No. Fishing is allowed within the park.	The reef is essential to Tobago's tourism-based economy. There is a lot of activity on the reef including tour boats, divers and craftsman	Just of the coast of Tobago the site is easily accessible but surrounded by other adjacent protected areas around the Islands.	EMA established the Buccoo Reef Marine Park Stakeholders Management Committee which oversees the management of the park. Management plan was developed by IMA in 1995 and was implemented by a park manager. The EMA intends to designate the reef as an ESA, under ESA rules 2001.	Best example of a complex reef system in the Caribbean. The reef system is comprised of reef garden, mangrove, shallow water and deep lagoon habitats boasting 40 species of corals and 70 species of tropical fish.
Phoenix Islands Protected Area	408,250 km^2 Largest marine conservation effort by a least developed country. These islands and surrounding waters cover 408,250 km2 and represent one of Earth's last intact oceanic coral archipelago ecosystems.	Kiribati first declared the creation of PIPA at the 2006 Conference of the Parties to the Convention on Biological Diversity in Brazil. Heritage site on Earth.	No. Fishing is allowed but somewhat limited. The administrators of the reserve have been criticized for the amount of fishing they allow.	General tourism is not allowed in the reserve. All parties wishing to enter the Phoenix Islands Protected Area need a permit. This includes private sailing vessels.	Yes. Right in the middle of the Pacific.	The Republic of Kiribati, in partnership with the non-governmental conservation organizations Conservation International and the New England Aquarium, has formed the Phoenix Island Protected Area Conservation Trust (PIPA Trust). Management includes Zoning and the requirement of permits.	*It is the sister site of Papahanaumokuakea Marine National Monument. *On January 30, 2008, Kiribati adopted formal regulations for PIPA that more than doubled the original size to make it at that time the largest marine protected area on Earth. In 2010 PIPA was added to the list of UNESCO World Heritage sites. It is the largest and deepest World. PIPA also protects

							important seabird nesting grounds. Five of the eight islands in PIPA are currently designated as Important Bird Areas by Birdlife International.
Channel Islands National Marine Sanctuary (California)	2365.736 Km^2	Designated in 1980 by the National Oceanic and Atmospheric Administration (NOAA)	The CINMS is made up of 13 protected areas around the islands, 11 of which are highly protected no-take marine reserves. Two of the areas – Painted Cave and Anacapa Island Marine Conservation areas – allow some extraction and fishing to take place.	*Many valuable commercial and recreational activities, such as fishing, shipping, and tourism occur in the sanctuary. *Every year almost 100,000 people visit the Channel Islands. *Visitors have an abundance of outdoor recreation options: diving, snorkelling, whale watching, kayaking, boating, sailing and fishing. *The program incentivizes ships in the Sanctuary to slow down, reducing pollution and minimizing fatal ship strikes to endangered whales.	*Surrounds five of the Channel Islands: San Miguel, Santa Rosa, Santa Cruz, Anacapa and Santa Barbara. *Channel Islands National Marine Sanctuary, located off the coast of Santa Barbara and Ventura counties in California. *The sanctuary's remote, isolated position at the confluence of two major ocean currents creates remarkable	A comprehensive ecosystem- based management approach is used to promote long term conservation of sanctuary waters, wildlife, habitats, and cultural resources, while allowing compatible human uses. In the CINMS, enforcement is provided through the National Park Service, the US Coast Guard, the California Department of Fish and Game, and the NOAA Office for Law Enforcement.	*The sanctuary is a special place for species close to extinction, sensitive habitats, shipwrecks and maritime heritage artefacts. *The mingling of cool, nutrient-rich waters from the north with warm currents from the south form a dynamic transition zone, home to microscopic planktons to blue whales. *After just five years, the CINMS had a higher abundance of targeted species, such as rockfish, sea urchin, and spiny lobster, inside the no-take reserves.

					biodiversity.		
Cordell Bank National Marine Sanctuary (USA – Northern California)	2069.616km^2	Established in 1989 to protect and preserve marine ecosystem,	Recreational and commercial fishing occur in the sanctuary. NOAA Fisheries and the California Department of Fish and Wildlife establishes the rules and regulations concerning fishing in this region. Find out more about fishing in the sanctuary. Recreational fishing within Cordell Bank National Marine Sanctuary is closed for most ground fish species.	The Sanctuary is a unique wildlife watching destinatio n at any time. Recreational diving is not recommended for a number of reasons. The upper reef areas on Cordell Bank are between 115 and 140 feet and Cordell Bank typically has strong currents that are extremely variable and can run in opposite directions at different depths. In order to protect the fragile reef community, anchoring is prohibited in areas shallower than 300 feet. A sanctuary permit can be issued for research or education purposes.	Southern-most boundary located 42 miles north of San Francisco, the sanctuary is entirely offshore, with the eastern boundary six miles from shore and the western boundary 30 miles offshore.	Located in federal waters, managed by the sanctuary superintendent and staff with oversight provided by the West Coast Regional Office in Monterey and the Office of National Marine Sanctuaries. A sanctuary advisory council has been established to provide advice on various issues throughout the sanctuary. Acting as the federal resource trustee responsible for managing requires an understanding of the authorizing legislation (National Marine Sanctuaries Act) management plan and permitting. Following requirements of these documents ensures protection	In order to protect the fragile reef community, anchoring is prohibited in areas shallower than 300 feet. A sanctuary permit can be issued for research or education purposes. Scientific research and monitoring are ongoing at the Sanctuary. Among those projects, the Foundation funded a major dive expedition that returned to Cordell Bank's remote coral reefs after a 30-year hiatus to assess its conditions. The fact that the reefs were well-preserved after three decades is testament to the importance of sanctuaries and their work.
Stellwagen Bank National Marine Sanctuary - Massachusetts	1355km^2	1992 Nominated by the Provincetown Center for Coastal studies in 1982 for sanctuary status the Gerry E Studds Stellwagen Bank National	Experienced captains bring party and charter fishing boats out to the bank to catch ground fish	The sanctuary provides a plethora of seabird species, so bird watching highly popular, as well as it being one of the top whale watching	Between Cape Ann and Cape Cod, in the southwest corner of the Gulf of Maine, is	Many concerns were expressed regarding enforcement in the Sanctuary. Several commenters noted that compliance with laws and regulations was unlikely without an enforcement presence and that enforcement was therefore critical to effective protection of Sanctuary resources. The general sentiment was expressed that existing laws need to be better enforced.	Scientists are engaging in marine research, conservation and education, with support from National Marine Sanctuary

		Sanctuary became one of the only 13 sanctuaries in the country in 1992.	and blue fin tuna while dive operators offer opportunities to explore shipwrecks and seafloor habitats.	destinations in the world. The seldom-visited environments are home to diverse wildlife and historic shipwrecks, and visibility is usually good.	Massachusetts Bay.		Foundation. Ground breaking acoustic mapping of hot spots and migratory patterns of whales and other acoustic-sensitive marine life leads informed shifts to ship traffic lanes that reduced fatal ship strikes by up to 80% and reduced disruptive noise.
Bird Island Group MPA (South Africa)	70.4 km^2 encompassing 4 islands.	Designated in 2004	Yes. The whole area is a no take zone.	No extractive activities are permitted and in 2006 Bird Island was declared as a restricted diving zone. In 2006 Bird Island was declared as a restricted diving zone.	Very close to the coast relatively close to a busy port (port Elizabeth) however being part of a wider national park the area is buffered by other protected areas on land and sea.	Since the establishment of a marine ranger team in 2007, there has been a significant decrease in illegal abalone poaching. Anyone diving within the reserve must attain a diving permit from the Manager of the reserve. To help ensure that fishing is not being carried out, only a limited number of permits are issued each year.	The MPA is an expansion of South Africa's third largest national park, the Greater Addo Elephant National Park, the immediate protection of the Bird Islands was considered a priority to control abalone poachers and to protect many of its vulnerable bird species, such as the African penguin and Cape gannet
Russian Arctic National Park	74,000km^2 (58,000 km^2 in sea area) covering a large remote area of the	Established in June 2009 and expanded in 2016. Some of the components of it have been protected for longer e.g Franz	Franz Joseph Land, the largest part of the area is a no take zone, however in	The area was first protected to try and promote tourism to the area although tourism numbers are still relatively	Reasonably Isolated, being situated in the middle of the Russian	Tourists are escorted and the tourism department ensures that they enforce compliance with environmental regulations.	In addition to preserving natural habitats, the area of the national park is important for preserving the

	Arctic Ocean, the northern part of Severny Island and Franz Josef Land .	Joseph Land (1994)	other areas fishing is allowed on a commercial scale.	low but it is still totally open to tourism.	Artic Ocean.		cultural heritage, which is related to the history of discovery and colonisation of the vast Arctic territories starting from the sixteenth century.
Hol Chan Marine Reserve	7.8km^2 Divided into four zones: The Reef, The Seagrass Beds, The Mangroves and the Shark Ray Alley.	Established 2nd May 1987, Shark Ray Alley officially declared zone D on August 31st 1999. -With funding from WWF and USA ID, after the draft management plan was approved by the Fisheries ministry and the local fishermen's co-operative.	Due to its protected status, what was once a depleted fishing area has now been allowed to re-generate. Proposed fishing bans were rejected and in the mid 1980s public consultation over establishing a marine protected area began. No fishing allowed in Zone A, and only sport in C, but sport and commercial allowed in zones B and D with a license.	Diving and snorkelling very popular. Hire boats and guides, usually one trip runs in the morning and one in the evening. Open 9-5 daily. The increasing numbers of tourists, which although increasing revenue to the reserve through fees, puts pressure on the facilities both within the reserve and the nearby towns of San Pedro and Caye Caulker.	Located approx. 4 miles southeast of San Pedro Town near the island of Ambergris Caye.	The establishment of the reserve in 1987 included four main goals. These were: *Preserving an area of the coral reef ecosystem*Providing recreational and tourist services while maintaining the utility of the area for fisheries*Providing an opportunity for education and research within the park *Conserving genetic resources. While fish stocks have increased, the fishing industry has continued to decline, and the management is faced with other problems: clearance of mangroves and other habitats in areas adjacent to the reserve, which affects the reserve.	Due to its protected status what was once a depleted fishing area has now been allowed to regenerate. The reserve is managed by the Hol Chan Marine Reserve Trust Fund Committee, which replaced the informal advisory committee which ran the reserve until 1994. The majority of the funds for the park's upkeep is generated from the fees charged to visitors for access to Zones A and D.